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Geology of the Indian Sub-continent

Geology of the Indian Sub-continent

OBSERVATIONS ON MINERALOGY, CYPSUM, MINES AND MOUNTAIN FORMATIONS

James Calder
J D Herbert

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GENERAL OBSERVATIONS

ON THE

GEOLOGY OF INDIA.

By JAMES CALDER, Esq.

It is singular to observe that, while England is ever ready to engage in enterprises to explore the secrets of nature, even in her most inaccessible retreats in other quarters of the globe, she should have shewn such supineness and indifference respecting the Natural History of her eastern dominions

In the colonial possessions of other nations, the whole field of nature has been explored and described by scientific and enlightened travellers; whilst, in India, it has been almost entirely neglected, with one splendid exception, in which the munificent patronage of the East India Company has enabled a distinguished Member of our Society to make magnificent discoveries in the vegetable kingdom May we not hope that the same patronage may be extended to other departments of Physical Science, and that, as Indian Botany has found its LINNÆUS, we may yet see the treasures of the Animal and Mineral kingdoms unfolded to us by a HUMBOLDT and a CUVIER, In the field of Geology, indeed, some steady progress has been made, which the superintending care of the lamented Voysey promised to ripen into a rich harvest: fatally, however, for science, this ardent philosophic inquirer was a martyr in the cause to which he was devoted. His loss can only be duly appreciated by those who are aware of the great local knowledge and experience which he possessed, added to his general scientific acquirements, which so peculiarly qualified him for the task he had undertaken. The labors of Dr. Voysey (which, had life been spared to him, a short period of time would have matured,) are not altogether lost. Some of his journals are in the possession of those who know how to estimate their value, and who, it is hoped, will be enabled to present the matter they contain to the public in as perfect a form as the incomplete state of the materials will permit. Availing ourselves partly of these materials, and of the scanty notices already in print, and the communications of the few valuable explorers now zealously engaged in scientific research, a few remarks may here be offered, by way of conveying some general view of the little we can yet pretend to know of the geological outlines of the vast field in the centre of which we are placed.

Casting our eye over the map of India, we are struck with the grand and extensive mountain ranges which form the principal boundaries. On the north we have the stupendous chain of the *Himalaya*, extending from the confines of *China* to *Cashmir*, and the basin of the *Oxus*; tha vast accumulation of sublime peaks—the pinnacles of our globe—is so extensive, that a plane, resting on elevations of 21,000 feet, may be stretched in one direction as far as the *Hindu Coh.* for upwards of 1000 miles, above which rise loftier summits, increasing in height to nearly 6000 feet more. Primitive rocks alone have been found to compose all that has yet been explored of the elevated portion of that chain; *gneiss* being, according to Captain Herbert, the predominating rock, along with *granite*,

mica-shist*, *hornblende-shist*, *chlorite-slate* and *crystalline lime-stone*;** on these repose *clay-slate*, and *flinty-slate*, and towards the base we find ***sand-stone composing the southern steps of the chain, and forming the N. E. barrier of the valley of the Jumna and Ganges, by which, and the diluvial plains of Upper Hindostan, this great Zone is separated from the mountain ranges of the peninsula. The opposite, or southern boundary of this valley, is of the same rock. Advancing to the south, we come to three inferior mountain ranges, on which the peninsular table land of India may be said to rest, or more properly, to which it owes its peculiar form and outline. We may consider these ranges separately, as the western or ***Malabar***, the eastern or *Coromandel*, and the central or *Vindhya*.

The principal in elevation, and most remarkable in continuity of extent, is the western range, which commences in *Candesh*, and runs along the Malabar coast, within a short distance of the sea, in an unbroken chain, to Cape Comorin, excepting where it is interrupted near its southern extremity, by the great chasm which opens into the valley of ***Koimbetúr***. The direction of this range deviates but little from north and south, bending a little eastward towards its southern extremity; its elevation increases as it advances southward, the highest points being probably between latitudes 10° and 15° N. where peaks of granite rise to 6000 feet and upwards.* The northern extremity of this range is entirely covered by part of the extensive *overlying trap formation*, to be more particularly described hereafter; extending, in this quarter, from the sea-shore of the northern *Concan*, to a considerable distance eastward above and beyond the Ghats, as far perhaps as the river *Tumboodra* and *Nagpore*. These rocks assume all the various forms of *basaltic trap*, passing from the *prismatic* and *columnar* (of which some fine specimens are to be seen opposite to *Bassin*, near Bombay) into the *globular*, *tabular*, *porphyritic*, and *amygdaloidal*; the two latter containing an interesting variety of included minerals peculiar to such rocks. The landscape here exhibits all the characteristic features of basaltic countries. The hills rising abruptly in perpendicular masses of a tabular form, or in mural terraces, piled on each other, like great flights of steps leading to some giant's throne, are frequently separated by immense ravines—the whole clothed with luxuriant forests of teak and other trees, producing some of the most beautiful and romantic scenery of India. The elevation of this part of the range seldom exceeds 3000 feet; but advancing to the south, its height gradually increases, and granitic rocks begin to re-appear, rising above the surface between 17° and 18° N. Latitude, and from thence, probably, continuing to form the summits of the chain, with little interruption, all the way to Cape Comorin. In nearly the same parallel of latitude, this trap formation is observed to terminate also on the sea-coast, a little to the north of Fort Victoria, or *Bankot*, where it is succeeded by the *iron-clay* or *laterite*,* (a contemporaneous rock associating with *trap)* which from thence extends as the overlying rock, with little interruption, to the extremity of the peninsula, covering the base of the mountains, and the whole of the narrow belt of land that separates them from the sea, exhibiting a succession of low rounded hills and undulations, and reposing on the primitive rocks, which occasionally protrude above the surface, as at *Mulwan*, *Calicut*, and some other points, where *granite*, for a short space, becomes the surface rock ; from the main land, the *laterite* passes over into Ceylon, where it re-appears, under the name of *Kabúk*, and forms a similar deposit, of some extent, on the shore of that island. Passing onwards from the western, or *Malabar* coast, round the extremity of the peninsula, we leave this extensive *iron-clay* formation, and crossing the *granitic* plains of *Travancore*, which are strewed with enormous blocks of primitive rocks, we arrive at the termination of the chain. Here the eastern and western ranges appear united, and, converging to a point within about twenty miles of Cape Comorin, end abruptly at the *Amboli* pass in a bluff peak of *granite*, probably about 2000 feet high, from the base of which a low range of similar rocks, forming a natural barrier to the kingdom of Travancore, extends southward to the sea. It is to be remarked however, that the junction of the two great lateral ranges, (viz. the Malabar and Coromandel,) seems to take place at the Nilgherry hills, which rising into the loftiest summits of the peninsula, form the southern boundary

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* In Mr. Babington's paper, in the 5th volume of the Geological Society's Transactions, the height of one peak, ***Bonasson*** hill, is stated to be 7000 feet above the sea, and in a recent description of the ***N·lgiri*** region, by Dr. Smith Young, the peak of ***Dodapet***, situated between 11° and 12° S. Latitude, and 76° and 77° E. Longitude, is said to rise to an elevation of 8700 feet—it is to be regretted that we have no published report of heights, by actual geometrical or barometrical measurements, of the principal summits of the mountain ranges of the peninsula.

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* We owe the first notice of this interesting Rock, which may, perhaps, be considered as peculiar to the Geology of this country, to Dr. Francis Buchanan, who gives the following description of it in his travels, vol. 3, p. 440. "What I have called indurated clay, is not the mineral so called "by Mr. Kirwan, who has not described this of which I am now writing. It seems to be the Argilla "Lapidea of Wallerius I. 395, and is one of the most valuable materials for building. It is diffused "in immense masses, without any appearance of stratification, and is placed over the granite that "forms the basis of Malayala. It is full of cavities and pores, and contains a very large quantity of "iron, in the form of red and yellow ochres. In the mass, while excluded from the air, it is so soft, "that any iron instrument readily cuts it, and is dug up in square masses with a pick-axe, and imme"diately cut into the shape wanted with a trowel, or large knife. It very soon after becomes as hard "as brick, and resists the air and water much better than any bricks that I have seen in India. I

" have never observed any animal or vegetable exuvia contained in it, but I have heard that such " have been found immersed in its substance. As it is usually cut into the form of bricks for build- " ing, in several of the native dialects, it is called the brick-stone (Itica Culla). Where, however, " by the washing away of the soil, part of it has been exposed to the air, and has hardened into a " rock, its colour becomes black, and its pores and inequalities give it a kind of resemblance to the " skin of a person affected with cutaneous disorders ; hence, in the Tamul language, it is called Shuri " Cull, or itch-stone. The most proper English name would be Laterite, from Lateritis, the appel- " lation that may be given to it in Science." It is observed also on the shores of Sumatra and the Straits of Malacca, reposing on granitic rocks, particularly at Malacca, where that formation extends many miles inland, corresponding, in all respects, with that of the Malabar Coast.

boundary of the great table-land and the northern barrier of the remarkable valley of *Koimbatur*, from the opposite side of which proceeds the continuation of the mountain chains in one central range to the southern extremity, as already described. The whole of this western chain, and the narrow coast which lines its base, is remarkable for the absence of rivers and vallies of denudation, and, consequently, of alluvial plains or deposits of any extent. The precipitous sides of the mountains rising in some places, (to the south of Goa,) almost from the sea, are, nevertheless, covered in general by forests of the tallest trees and impenetrable jungles, which admit of gaining but a vague and scanty knowledge either of their geological features, or the mineral treasures with which they may abound.

The Island of Ceylon presents so much the appearance of having once formed part of the Continent of India, and there is such a striking similarity in the nature of its principal rocks (which are chiefly primitive,) to those of the mainland immediately opposite to it, that some notice of its geological structure should not here be omitted, of which Dr. Davy's valuable work affords the following interesting and scientific description.

" In Ceylon, nothing is to be observed of that order of succession of rocks that occurs in Saxony and England, and many other parts of Europe. Uniformity of formation is the most remarkable feature in the geological structure of the Island; the whole of Ceylon, with few exceptions, consists of primitive rock unconnected with any other class of rocks, exclusive of those of very recent formation. Another remarkable geological circumstance is, that though the varieties of primitive rock are extremely numerous, almost infinite, yet the species are very few and seldom well defined.

" The most prevailing species is *granite* or *gneiss*, the more limited are *quartz* rock, *hornblende* rock, and *dolomite* rock, and a few others which may be considered under the head of embedded minerals.

" The varieties of *granite* and *gneiss* are innumerable, passing often from one into another, and assuming appearances for which, in small masses, it would be difficult to find out appropriate names, depending on composition and the proportions of the elements—or addition of new ingredients; regular *granite* is not common, *graphic granite* still rarer, it occurs at Trincomalee—neither is *sienite* common, it occurs in the Candyan provinces. Well formed *gneiss* is more abundant than *granite*, it frequently consists of white *felspar* and *quartz* in a finely crystalyzed state, with layers of black *mica*, containing numerous crystals of light coloured *garnets*. A similar rock is found on the opposite Continent, in the mountains at *Cotallum*, and affords one amongst other evidences of a conformity, if not indentity, in geological character. Both the *granite* and *gneiss* of Ceylon, are much modified by an excess or deficiency of one or other of the ingredients. When *quartz* abounds in a fine granular state, the rock looks like *sand-stone*. When *felspar* or *adularia* abound, it acquires a new external character. This variety is common, and in some places it contains so much of these minerals that it may be called *adularia*, or *felspar rock*. When *mica* prevails in *gneiss*, (which is rare) it acquires not only the appearance, but very much the structure of *mica slate*.

The more limited varieties of *primitive rocks*, as *quartz*, *hornblende*, and *dolomite* rock, seldom occur in the form of mountain masses. The rocks of recent formation are *lime-stone* and *sand-stone*. The former is confined to the northern shore of the Island, where it appears to be still forming in the coral shallows of the adjoining sea. The other, (sand-stone) a rock of pretty general occurrence along the shore of the Island, which it may be said to surround by an interrupted chain chiefly between high and low water mark." The further detailed description of these rocks given by this scientific observer, and his account of the rich variety of beautiful minerals abounding in that Island, will be found highly interesting and instructive.

Proceeding on to the eastern side of the peninsular, and northward, along the foot of the mountains, we observe a country differing very considerably from the Malabar coast in appearance and geological character. The plains of the Coromandel coast form rather a broad though unequal belt of land between the mountains and the sea, exhibiting the alluvial deposits of all the rivers and streams that descend from the southern portion of the table land. The mountain chain that forms the eastern boundary of the peninsula, begins to diverge eastward where its continuity is interrupted by the valley of *Koimbatur* (already mentioned) From thence it breaks into a succession of parallel ranges, inferior in elevation and in unbroken continuity to the western chain; and in the further progress northward, after branching off into subordinate hilly ranges, occupying a wide tract of unexplored country, and affording vallies for the passage of the great rivers, that drain nearly all the waters of the peninsula into the Bay of Bengal, this eastern range may be said to terminate at the same latitude as that of the commencement of the western. *Granitic* rocks, (principally *sienite,*) seem to form the basis of the whole of these eastern ranges, appearing at most of the accessible summits, from Cape Comorin to Hyderabad. Resting on the *granite*, *gneiss*, and *mica-slate*, that form the sides and base of the mountains, are sometimes seen *clay-slate*, *hornblende-slate*, *flinty-slate*, *chlorite* and *talc-slate*, and primitive or crystaline *lime-stone*, affording, in some places, marbles of various colours, as in the district of *Tinnivelly*, near *Cotallum*, where *granite* is observed rising above the surface, in remarkable globular or concentric lamellar concretions, and in apparently stratified masses, forming low detached hills, the strata of which dip at an angle of about 45° to the S. W.* Partial deposits, of the overlying rocks exist in this district, and of the black cotton soil, supposed to be produced by the decomposition of *trap rocks*. In the neighbourhood of Pondicherry, there are beds of compact *shelly lime-stone*, and some remarkable siliceous petrifactions, chiefly of the tamarind-tree, which have never been well described. The bed of the *Caveri*, or rather the alluvial deposits in the vicinity of *Trichinopoly*, produce a variety of gems corresponding to those of Ceylon: in general, however, the surface of the level country, as far north as the *Pennar* river, seems to consist of the debris of *granitic* rocks, and plains of *marine sand*, probably left by the retreat of the sea, with occasional alluvial deposits, and partial beds of *iron-clay*, and detached masses of other rocks of the overlying class. In approaching the *Pennar* river, the *iron-clay* formation expands over a larger surface, and *clay-slate* and *sand-stone* begin to appear. In the hills behind *Nellore*, are found specimens of a very rich copper ore, yielding from fifty to sixty per cent. of pure metal, according to Dr. Heyne, besides argentiferous *galena*.

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* These appearances, hitherto considered foreign to the nature or aspect of *granite rocks* in ther parts of the globe, might be deemed questionable here, did they not coincide with similar ppearances throughout the peninsula, and remarkably so with those of the Ceylon *granites* as thus lescribed by Dr. Davy. "In structure, the granitic varieties most commonly exhibit an appearance of stratification. It is not easy to decide with certainty whether this appearance is to be attributed to the mass being composed of strata, or of large laminæ or layers. I must confess I am more disposed to adopt the latter notion. I have found some great masses of rock decidedly of this structure;—masses almost insulated, quite bare, several hundred feet high, in which the same layer might be observed spreading over the rock, like the coat of an onion;—and which, if only partially exposed, might be considered a strong instance of stratification;—and, if examined in different places, on the top and at each side, might be considered an extraordinary instance of the dip of the strata in opposite directions. With this hypothesis of the structure of the rocks, the appearance of stratification in all the granitic varieties may be easily reconciled."

It is to the observation of Drs. HEYNE and VOYSEY, that we owe all the information we yet possess of the vallies of the *Pennar*, the *Krishna*, and the *Godaverí* rivers. This interesting tract of country is not more remarkable as the ancient source of the most valuable productions of the mineral kingdom, being the repository of the Golconda diamonds;—than for the extraordinary geological features which it presents. The *Nella Malla* range of mountains; in which the *diamond-breccia* is found, is described by Dr. VOYSEY, as exhibiting a geological structure, that cannot easily be explained by either the Huttonian or Wernerian theories, the different rocks being so intermixed with regard to order of position, each in its turn being uppermost, that it is difficult to give a name to the formation that will apply in all places: the *clay-slate* formation is the name he has adopted, under which are included *clay-slate*, every variety of *slaty lime-stone*, *sand-stone*, *breccia*, *flinty-slate*, *horn-stone-slate* and a *tufaceous lime-stone*, containing, embedded in it fragments, (rounded and angular) of all these rocks—all passing into each other by such insensible gradations, as well as by abrupt transitions, as to defy arrangement, and render description useless. It is bounded by *granite*, which passes under it, and forms its base, some elevated points, such as *Naggery Nose*, having only their upper third composed of *sand-stone* and *quartz*, while the basis is generally *granite* or *sienite*.

The rocks above enumerated, with beds of compact *lime-stone*, resembling *lias*, of various colours, and the addition of the *iron-clay* and *basaltic* rocks, occupy extensive portions of the valleys of the *Krishna* and *Godaveri*, covered in some places by the black *trap* soil; a *sienitic granite* however, composed of *hornblende*, and sometimes *mica*, with *quartz*, *felspar*, and *garnets*, interspersed, forms the basis of the ranges that separate these rivers. From *Condapilli* northward, the *granite* is often penetrated, and apparently heaved up by injected veins or masses of *trap* and dykes of *green-stone*.

green-stone. We hope soon to be enabled to lay before the Society, a detailed description of these formations, accompanied by sections of the strata between Madras and Hyderabad. The waters of the *Krishna* and *Godaveri* expand as they approach the sea, dividing into numerous branches, and depositing their alluvial contents during inundations over the low level tract that separates them: these deposits consist, according to Dr. HEYNE, of a black earth, resting on *indurated marl*, and composed partly of the debris of *trap* rocks, but chiefly of decayed vegetable matter, yielded by the extensive forests through which these rivers flow. Here may be noticed a characteristic difference that marks the alluvial deposits of the principal river of the south—the *Caveri*. This river, flowing in a long course through the Mysore country, over an extensive and generally barren surface of *granitic* rocks, with scarcely any woods or jungle on its banks, seems to bring down little or no vegetable alluvium; but a rich clay, produced by the *felspar*, which predominates in the *granites* of the south, intermixed with decomposed *calcareous conglomerate*, rendering the plains of Tanjore the most fertile portion of the south of India.

Passing on to *Vizagapatam* and *Ganjam*, *granitic* rocks, chiefly *syenite* and *gneiss*, predominate, and are occasionally covered by *laterite* The *granite* of *Vizagapatam* assumes a new and singular appearance, being small-grained, and intermixed with amorphous garnets, in rounded grains, or specks. This peculiar rock passes into the Province of Cuttack. The only information we possess regarding that interesting district, is derived from Mr. STIRLING's valuable paper in the last volume of the Asiatic Researches. Rocks of the *granitic* class form the basis and principal elevations of this district; some of them are remarkable for their resemblance to *sand-stone*, and abounding in imperfectly formed *garnets*, disseminated throughout, with veins of *steatite*. Here some traces of coal have recently been discovered, which is likely to be productive, and gold is found in the sands of the *Mahanadi*, brought down probably from the valley of *Sambhalpur*. We next trace the *laterite*, as the overlying rock, through the district of *Medinipur*, and thence continuing northward by *Bishenpur* and *Bancora* to *Bírbhúm*, reposing sometimes on *sand-stone*, but more frequently on *granite* or *gneiss*. At *Bancora*, the calcareous concretion called *Kankar*, begins to cover the surface of the *granitic* and *sienite rocks*. which rise above the surface to considerable elevations in that district.

Thence we pass on to the great coal field that occupies both sides of the river *Damoda*. The boundaries of this formation have not yet been accurately ascertained: to the southward we trace its associating rocks,(*sand-stone* and *shales*) to within a few miles of *Raghunáthpur*, reposing on *granite* and *sienite*—about forty miles north by east; from that place we come to the first colliery ever opened in India. The late Mr. JONES, an enterprising miner, had the merit of commencing these works in 1815, at a place called *Rání Ganj*, on the left bank of the *Damoda*. Mr. JONES describes this as the N. W. coal district of Bengal: he states that he observed the line of bearing for sixty-five miles in one direction, its breadth towards *Bancora*, (on the S. W. side) being not more than eleven or twelve miles from the river; and he conjectures that the same coal formation crossing the valley of the *Ganges*, near *Catwa*, unites with that of *Sylhet* and *Cachar*, which he denominates the N. E. coal district, and from which abundant specimens of coal have been produced. An accurate survey of this extensive and valuable deposit seems to be called for, by obvious considerations of the most important public advantage.

The principal rocks that compose this formation are varieties of *sand-stone*, *slate-clay*, and *shales*, with occasional dykes and veins of *trap* and *green-stone;* the *shale* immediately covering the coal, abounds with vegetable impressions, and some animal organic remains; amongst these, Dr. VOYSEY distinguished a *phytolithus*, a *calamite*, a *lycopodium*, and one specimen of a gigantic species of *patella*. The *shale* passes into *slate-clay*, above which succeeds a *gritty*, *micaceous*, *brownish-grey*, *sand-stone*, here and there becoming *indurated* and *slaty*—this forms the surface rock all over the coal district, rising into low round - topt hills and undulated grounds. In the coal pits (three in number,) which have only yet been sunk to a depth of about ninety feet, seven seams of coal have been met with, one of which exceeds nine feet in thickness: the quality of the coal (which is now consumed largely in and about Calcutta,) somewhat resembles the Sunderland coal, but leaves a larger proportion of cinders and ashes.

Proceeding northward and westward, from *Bancora*, and the *Damoda* river, the road to *Benares* passes over *granitic rocks*, of which the ranges of hills on the left, and the whole country, as far as the *Sone* and round by *Shírgháti* and *Gaya*, is probably composed. On approaching the *Sone* river, and crossing the hills behind *Susseram*, *sand-stone* begins to appear, and continues to be the surface rock, with probably only one considerable interval, all the way to *Agra*, forming, as before noticed, the southern barrier of the valley of the *Ganges* and *Jumna*; *that interval* occurs in the low lands of *Bundelkhand*, where the remarkable isolated hills, forming ridges, running S. W. and N. E. are all *granitic*, the high lands being covered with *sand-stone*. This brings us back to the rocky plains of Upper Hindustan, and to the last of the three principal mountain ranges first alluded to. The *Vindhya Zone*, crossing the Continent, from east to west, may be said to unite the northern extremities of the two great ranges already described, which terminate nearly in the same parallel of latitude, forming, as it were, the base of the triangle that elevates the table land of the peninsula. This great chain, yielding little in classical character to the *Himálaya*, intersects the heart of the country, and is distinctly traceable, even in our very imperfect maps, running about S. 75° W. from the point called the *Ramgerh* hills, towards *Guzerat:* this range has numerous divisions and a multitude of names, almost every district giving a change of denomination, but to the eye of a Geologist who considers things on an extended scale, there is a parallelism in the disjointed parts, and a general connection and dependance on the central range; the substrata prove this fact, for in every case they preserve that parallelism. The great surface formations of central India and the *Dekhin,* are the *granitic,* (including always *gneiss and sienite)* the *sand-stone,* and the *overlying rocks;* the latter exceeding in their extent those of any other country. The *basaltic trap* formation extends northward all over *Malwa* and *Ságar,* and eastward towards *Sohagpur* and *Amerakantak;** thence proceeding southward by *Nagpur,* it sweeps the western confines of *Hyderabad,* nearly to the fifteenth parallel of latitude, and bending to the N. W. connects with the sea near *Fort Victoria,* as already noticed, composing the shores of the *Concan* northward, all the way to the mouth of the *Nerbadda,* covering an area of upwards of 200,000 square miles. It overlies *sand-stone* in the district of *Ságar,* and hence may be inferred, that a portion of it at least is posterior to *sand-stone:* it possesses the common property of *trap* rocks in general, viz. that of changing the nature of every other rock which comes in contact with it; and in the district of *Ságar,* it is always associated with an earthy *lime-stone,* which seems to have undergone great change, strongly indicating the agency of heat. According to Captain FRANKLIN, the *sand-stone* deposits are very regular both in their deposition and geological character, and cannot well be mistaken; their general parallelism to the horizon, and their saliferous nature, appear to him to identify them with the *new red sand-stone* of England, whilst the *red marle,* and its superincumbent variegated or mottled variety, (called by Werner *bunter-sand-stein*,) together with the deposits of *lias lime-stone*, place the matter almost beyond a doubt. In using the term *new red sand-stone*, however, it must be understood, as it is in England, to comprise all that series of beds which intervenes between the *lias lime-stone* and the *coal measures*; admitting which, he conceives that the water-falls of *Bundelkhand*, which occur in the lowest steps of the *Vindhya range*, will afford a series of formations corresponding perfectly with those of England; and to that school, therefore, our attention should be directed, in order to arrive at satisfactory conclusions regarding it.

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* It is expected, that the limits of this eastern deposit of *trap* will soon be more acurately determined by Captain FRANKLIN.

On the western side of India it is, as we have seen, covered by over lying rocks, as at *Ságar:* it appears, however, flanking the large primitive branch which rums to *Udaypur*, on the side of *Guzerat ;* and to the north it sweeps into the desert to an unknown extent. A paper of Mr. Fraser's, in the London Geological Transactions, proves this fact, even if we had not the more substantial evidence of rock-salt, which is there produced in abundance.

The next of the great surface rocks of central India, is large-grained *granite*, frequently passing into *gneiss*, generally composed of *quartz*, *flesh-coloured felspar*, a little brown or black *mica* and *hornblende;* it varies, however, in appearance, and also in the proportion of its constituents; but, generally speaking, it contains large crystals of *felspar*, and is, consequently, much subject to decomposition; Captain **Franklin** has specimens shewing its unequivocal passage into *green-stone*, and, in some instances, it resembles *green-stone porphyry*, as in a small water course at the foot of the *Bairamganj Ghat*, in *Bundelkhand:* it sometimes also, he observes, resembles *euphotide*, and, in many cases, it would be difficult to decide whether it be *granite* or *sienite;* this circumstance renders it desirable that it should receive further examination: it extends all over the southern part of the peninsula, after the *trap* and *sand-stone* disappear, and it lies so near the surface that it is constantly protruding through the superior strata all over India, all the valleys of denudation bring it to light, and the plains of *Bundelkhand* are entirely composed of it; the veins of *quartz rock*, with which it is constantly associated, forming, in general, the spine of the hills.

The vallies of denudation are almost the only places where the *primitive stratified rocks* can be observed with advantage, and even there it is rare to obtain a good section of them; it is not because they do not exist in India, as in other countries, it is because they are, for the most part, buried beneath a mass of superincumbent *trap;* still however, there are occasional spots where they are found in *situ,* as in the *Udaypur* branch of the primitive chain, the small primitive ramification on the verge of the *trap* near *Jabalpur,* and many other places not necessary to mention; but the vallies of denudation sometimes exhibit a series, as in the bed of the *Nerbudda* river, at *Beragerh,* near *Garrah,* and it is there chiefly that these rocks can be studied advantageously.

With regard to the rocks of more recent formation than *sand-stone,* India is peculiarly barren; but this circumstance, above all others, renders its geology interesting—if it be in reality so, whence does such a remarkable distinction proceed? the reply may comprehend a solution of the most important phenomena of the science.

The *lias* formation is as yet known only from Captain FRANKLIN's researches: he has found it in *Bundelkhand* in *situ,* reposing on *red marle,* or *new red sand-stone;* its general geological character appears to correspond with the same formation in England, and its light-coloured or most compact varieties have been found to answer some useful purposes of lithography, although none has yet been discovered equal to the true lithographic stone of Europe. Neither *oolites* nor *chalk*, have yet been discovered by Captain FRANKLIN, although he has traversed not only the range of hills, at the foot of which the *lias* is found, but the whole adjoining country, and the absence of these rocks in the tract that has fallen under his examination, forms, in his opinion, a remarkable peculiarity.

This, therefore, is one of our great objects of research, viz. to ascertain whether in all other parts of India, the *oolitic* and later regular formations are thus wanting, nor should the concretionary rocks be excluded from this enquiry; of these the most remarkable is that singular calcareous deposit called, in the Bengal provinces, *kankar*, and known by other names in the south of India. It appears in a variety of forms and in different relative positions in different places. Sometimes in *nodules*, *globular concretions*, or *rolled masses*. scattered over the surface of valleys and rocky plains; at other times in horizontal beds and layers, at various depths in the alluvial deposits of the rivers and plains of Hindustan. Its prevalence is very extensive, although less abundant in the southern quarter of the peninsula; neither has it yet been observed on the Malabar Coast,* and in Bengal it appears to be bounded to the eastward by the *Gandak* river. From its peculiar appearance in some places it has been considered as *calc tuff*, and by some mineralogists would, perhaps, be classed under that denomination. Common *kankar*, on analysis, is found to contain the elements of *oolite* and *chalk*. May not this concretionary formation therefore, which seems peculiar to India, be the ruins of what, under different circumstances, might have become regular *oolitic* strata? Captain FRANKLIN observes, that these irregular beds of *kankar*, which are found following every water course, and forming its banks, have often the appearance of having been deposited under circumstances peculiarly unfavourable to regularity; and it may be asked, to what agency but that of running and turbulent water can such appearances be satisfactorily ascribed?

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* It should be remarked, that the prevailing *Laterite* of that coast is characterised by a proportion of *Calcareous* matter in its composition.

The absence of those regular formations which are known to exist in other countries is, however, a geological question of the first importance that must not be hastily taken up or hypothetically assumed, and nothing but reiterated and satisfactory proof of their non-existence ought to be considered admissible. A careful discrimination is also necessary, so as not to confound with *chalk*, the numerous *steatitic* deposits which are known to exist, and are used in India as substitutes for it; the *oolites* indeed cannot well be mistaken, because their peculiarity of structure readily points them out; but the most important of all distinctions are, *geological position* and *association*, without attention to which all observations will necessarily lose much of their value as useful facts.

With regard to organic remains, (the most interesting of all the branches of geological science,) it is to be feared that India is not likely to prove a productive field. The coal strata, when public spirit and enterprise shall excavate them, will, probably, afford other varieties of impressions of vegetables and fishes, besides those already mentioned, and the *lias lime-stone* may contain specimens of the *sauri* tribe; but hitherto, the most striking phœnomenon in Indian geology is the almost total absence of organic remains in the stratified rocks and in the diluvial soil. *Sharks'-teeth* and *palates*, are found in the diluvian banks of the *Ganges*. In the *lime-stones* and alluvial deposits of *Sylhet* and *Cachar*, the interesting researches of Mr. SCOTT, have discovered *nummulites* and other shells, which appeared to Dr. VOYSEY to be *diluvian*, or even of modern existence, live shells of exact resemblance to them being found in the vicinity, with the exception of *nummulites*. Silicified-wood has been found in the diluvium of *Calcutta* and *Jebbelpur;* but bones of animals have never yet, we believe, been discovered either in diluvium or in stratified rocks. In this branch however, the extensive deposits of fossil bones recently discovered in *Ava*, apparently antediluvian, and perhaps the yet unexplored caverns in the *lime-stone* strata of *Sylhet*, *Cachar*, and *Asam*, promise a field for future successful research. Of the alluvial delta of Bengal, the bed of the *Ganges*, and the country to the eastward of it, we are at present unable to add anything of importance to the information given by Dr. Adam, Mr. Scott, and Mr. Benson, in their interesting communications already published, nor do we possess as yet sufficiently connected materials for giving even a superficial view of the geological outlines of the countries to the north-west, but we may look to some zealous explorers now actively employed, for an early extension of our geological knowledge in that direction.* The Bombay Literary Society will, no doubt, be able to collect much interesting information from that quarter, especially as it is understood that the coal field long since discovered in *Cutch*, by the late Captain McMurdo, is now likely to be worked. I have said nothing about the lead mines of *Ajmer*, nor of the *ores* of that and other metals that have been discovered and worked in former times, in various parts of India, particularly the extensive and important class of *iron ores*, which abound almost every where, and in greater variety than, perhaps, is to be found in any other country.†

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* Specimens said to be from the Province of *Cutch*, have been seen by Dr. Hardie, which lead him to expect that we shall, in all probability, discover, in that quarter, some of the newer class of rocks posterior to the *lias*, which are in so remarkable a degree wanting in other quarters of India.

† Captain Franklin has been engaged in examining the *iron ores* of the valley of the *Nermada*, and Captains Coulthard and Dickson, in the districts of *Sagar* and *Ajmer*, have furnished interesting communications, which will appear in our Researches.

From the above desultory observations, it would appear, that the Geology of India is far less complex, than that of most other countries, of the Geology of which any thing is known. It is said* that, instead of twenty different formations, as in England, there are in India only four, viz. The *granitic*, the *sand-stone* and *clay-slate*, the *trap*, and the *diluvial;* with their respective subordinate rocks, each of which formations possesses characteristics in common, that strongly mark their cotemporariety. This conclusion, however, requires some modification. We have the *primary* series, both stratified and unstratified, in complete succession. We have the *transition* class—the *carboniferous* order, and also the *secondary* class—nor does there appear to be any thing anomalous, until we ascend in the series to the *overlying* rocks of the *trap* family ; these rocks, as has been shewn in another part of this paper, form the most striking feature of our Geology, and as some of them at least are proved to be of a later epoch than *secondary sand-stone,* it is apparently to the period of their formation (whatever may be their origin,) that we must refer the commencement of anomalous appearances.

In this view of the Geology of India, therefore, our safest plan will be to confine ourselves as much as possible, within simple rules, and to such terms of nomenclature as may least embarrass the subject. The best writers in the Transactions of the Geological Society of London, seem to have very generally adopted the synoptical arrangement, which is given in the introduction to Conybeare, and Phillips's Outlines of the Geology of England and Wales ; and it is to be presumed that they have done so after due consideration. The English Geologists have certainly shewn, that they are less inclined to theorise than those of other countries: indeed, the series of their rocks is so complete, that they have not needed it: their labours have consisted in the accumulation of facts, and the scene of their operations being so confined, compared with the extensive field in other countries, they have been able to visit almost every formation with minute investigation This we have no present hope of being able to accomplish in India; but we may, nevertheless, follow their example in the simplicity of our arrangement, and in the precision of our nomenclature; and it would seem that our adoption of the synoptical arrangement above mentioned, as far as practicable, by leading to an uniformity in our pursuits, and, what is still more important, to an identification of our principal Geological Strata with those of Europe, will preserve us from many errors: it will, besides, prove advantageous in rendering our descriptions more intelligible to all persons in England, who may be interested in the Geology of India.

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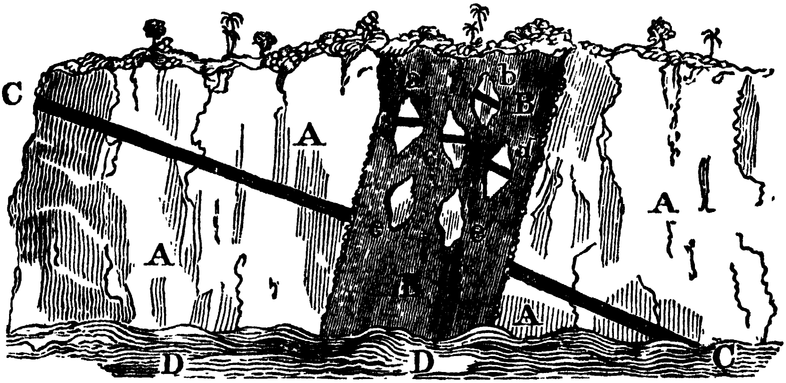
* By the late Dr. Voysey in a letter to Dr. Abel

NOTE.

The occurrence of *basaltic veins*, traversing the *granitic rocks* of Central and Southern India, is not unfrequent, and has been particularly noticed by Dr. Voysey.

In travelling from Madras to Mangalore, many years ago, I observed one of those veins possessing peculiarities that may render its description somewhat interesting to the Geologist. It occurs in the rocky bed of a small detached branch of the river *Caveri*—at a spot distant about two miles west from the fort and island of *Seringapatam*; here the prevailing rock is SIENITIC GRANITE, which, on the left bank, rises in nearly a perpendicular face to about fifteen or twenty feet above the stream. In this rock, there is a vertical *dyke*, or *vein* of compact *basaltic trap*, ten or twelve feet broad, and of uniform thickness (its sides being parallel) from top to bottom—a small vein of *black scaly hornblende*, about two inches in thickness, traverses the *sienitic rock*, obliquely, and it is distinctly perceptible that this vein has been disrupted by the *whyn dyke*, for, in the midst of the *basaltic vein*, there are fragments of the *sienitic rock;* some of them from one to two feet in diameter, which contain portions of the *hornblende vein*, so perfect and entire as to indicate the precise spot from which they must have come; and it is particularly remarkable, that all these fragments appear to have been carried upwards, considerably above the leval of the *hornblende vein* which, with its containing rock, is obviously of anterior origin to the *trap* vein—a fact that is also indicated by the superior induration and partially scorched appearance of the *sienite* along its line of contact with the *basalt.*

The following sketch represents the appearances here described:—



A—The main rock of the bed and bank of the river, *sienitic granite.*

B—The *basaltic* vein.

C—The *hornblende* vein.

D—The bed of the river.

a. b. c. d.—Fragments of the main rock, containing portions of the *hornblende* vein evidently forced upwards.

e. e.—Other fragments of the main rock, without the *hornblende* vein.

II.

ON THE

GEOLOGY

OF A PORTION OF

BUNDELKHAND, BOGHELKHAND,

AND THE

DISTRICTS OF SAGAR AND JEBELPUR.

BY CAPTAIN JAMES FRANKLIN,

First Bengal Cavalry, M. A. S.

(READ FEBRUARY 11, 1828.)

HAVING lately had an opportunity of examining the Geological features of a portion of the provinces of *Bundelkhand* and *Boghelkhand*, and also of the districts of *Ságar* and *Jebelpur*, I have great pleasure in submitting the result of my observations to the Asiatic Society, and I beg to offer to their notice, the *lime-stone* formation, which is found on the summit of the second range of hills, as it appears to correspond with the *lias lime-stone* of England, and I am not aware, that this formation has heretofore been shewn to exist in India.

The tract of country to be here described, is a portion of the northern steps of the *Vindhya* mountains; for, although the ranges of hills have separate names, such as *Bindáchal*, *Bandair*, *Kymur*, &c. which serve for local distinction, yet viewing them as Geological portions, they must necessarily merge in the common denomination of that great zone of which they are component parts.

I commenced my route at *Mirzapur*, a place of considerable traffic on the river *Ganges*, and ascended the first range of hills at the pass of *Tára*. The tract between these two places is not interesting in a Geological point of view, being covered with alluvium, which either reposes upon beds of *kankar*, or is intimately intermixed therewith, and near the hills, the *kankar* is found by the excavation of wells, to repose on *sand-stone*.

The first range of hills is composed entirely of *sand-stone*, horizontally stratified, consisting of fine grains of *quartz*, cemented by clay, and coloured more or less by the *red oxide of iron*; it is occasionally compact, but its general character is rather friable, than compact, and it sometimes contains galls of clay: it is also saliferous, as is evident from the plains below being saturated with salt, and also from the salt works, on the banks of the *Tons* river; in many parts, it has sufficient cohesion for architecture, and is quarried near to the *Tára* pass for that purpose: connecting these circumstances, therefore, and a comparison of it, with specimens of the same rock from England—it appeared to me to correspond with the new *red sand-stone*.

From the crest of the *Tára* pass, to the foot of the second range of hills near *Kattra*, the whole tract is a platform, varying only from a perfect level, by occasional protrusions of the rock, which form small collines, and sometimes hills; this platform increases in elevation towards the south-west; in the part where I passed, except immediately on the crest of the hills, common *kankar* is very prevalent, either intermixed with the alluvium, or in beds, as in the channel, and on the banks of the *Bailan nadi* at *Barcnda*, where it appears to be indistinctly stratified—and contains fragments of *sand-stone:* this part of the range is not rich either in minerals or metals; but another portion of it, near *Pannah*, is remarkable for containing diamonds, and still further west, are the extensive iron mines of *Katola.*

I ascended the second range of hills at the pass of *Kattra*, and found near the top of it a stratum of *red* and *bluish green slaty marle* interstratified with *sand-stone*, in thin laminæ, and surmounted at the top by variegated *sand-stone;* these beds resembled the *red marle* of England, and in furtherance of the conjecture that they may be so identified—I will add that salt is manufactured in the village of *Kattra.* The *slaty marle* rested upon massive beds horizontally stratified, resembling, as far as I can judge from description, Dr. MACCULLOCH's lowest *sand-stone*, 2d Div. F. the upper part of which was *schistose*, containing a little *mica* and tinged slightly *green*, but the lower part was massive, and coloured by the *brown oxide of iron.*

The summit of the second range is a platform, like the former, varying only from a perfect level by the same description of undulation which I have described above; like the former also it increases in elevation towards the south-west, and in order to examine its composition, I visited all the water-falls between the *Kattra* pass, and the *Tons* river.

The first of these cataracts is near the village of *Bilohi*, about twelve miles west of the pass of *Kattra*, the fall of water is three hundred and ninety-eight feet, and the escarpment is nearly perpendicular, the lowest bed is a thin stratum of fine argillaceous *sand-stone* tinged deeply by the *red oxide of iron* and containing *mica* disseminated in small particles; upon it reposed a bed of *siliceous sand-stone*, tinged green, and intercalated with *slate clay*, or *shale*, of the same colour; these beds were compact and hard, but upon them was a thick stratum of variegated *sand-stone*, having an argillaceous cement, which continued to the surface.

From the cataract of *Bilohi*, I proceeded to that of *Bouti*, ten miles further west; this waterfall is exceedingly picturesque, not so much from the fall of water, which is four hundred feet, as from the extent of the cirque; the lowest rock is greenish white arenaceous *sand-stone*, not quite so compact as that of *Bilohi*, though, perhaps, it may be a continuation of the same, and upon it, (commencing at the depth of three hundred feet below the surface), is a variegated or mottled stratum, then follows a lilac red, or purplish stratum, which becomes more and more light coloured, so as to approach salmon colour, before it reaches the surface.

The enormous masses of *kankar* which have been rolled down by torrents into this chasm, are very remarkable; the surrounding fragments of *sand-stone*, are all worn, or their edges rounded by the attrition of water; but these masses remain unaffected, and continue to defy both the force of the stream, and the ravages of time.

From *Bouti*, I proceeded to *Keuti*, twenty-four miles further west; here the fall of water is two hundred and seventy-two feet, and the depth of the escarpment three hundred and twenty feet: the lowest stratum of rock is the variegated or mottled *sand-stone* mentioned above, and upon it reposes the lilac red, or purplish stratum, which last, commencing at the depth of two hundred and fifty feet, continues to the surface, varying only in consolidation, and becoming lighter in colour.

From *Keuti*, I proceeded to the cataract of *Chachai*, where the fall of water is three hundred and sixty-two feet; but here is no other rock than the lilac red, or purplish stratum, which varies as at *Bouti* and *Keuti*, both in colour and consolidation as it approaches the surface

From *Chachai* to the cataract of the *Tons* river, is a short distance; the volume of water is greater than in the other cataracts, but the fall is less, being only two hundred feet, and the rock resembles that of *Chachai* so exactly, that it needs no further description.

These cataracts, though there is nothing stupendous about them, have still enough of interest to recommend them to the notice of travellers, and they have the advantage of being easily approached; they are sufficiently magnificent to occasion a slight impression of awe mingled with pleasure, at first sight, and this feeling is perhaps enhanced, by coming on the brink of the precipice almost unawares; they are also very picturesque, and deserve the talents and skill of an able artist.

In a geological point of view, they are more interesting, for, from their composition, it is evident, that the whole range of hills in which they are situated, is a mass of *sand-stone*, they shew also, that there is a valley in the subjacent strata in this part, by exhibiting distinctly the plane of inclination of the variegated stratum, which being uppermost at *Bilohi*, central at *Bouti*, lowest at *Keuti*, and disappearing below the surface at *Chachai*, plainly denotes a subsidence, the axis of which is, perhaps, somewhere about the *Tons* river, and this appears to be the thickest part of the formation

From the cataract of the *Tons* river, I proceeded via *Simmeriya*, *Birsinhpur*, *Hat,hi*, *Sohawel*, and *Nagound*, to *Lohargong*, and met with no other rock than *sand-stone*, sometimes ferruginous, sometimes slaty, and sometimes containing *mica*, until I arrived at *Hat,hi*, where it changed to argillaceous lias *lime-stone*.

At *Birsinhpur*, in the bed of the small river which runs near the town, is a stratum of *red marle* or *sand-stone*, containing laminæ of *calc-spar*, distinctly interstratified; at *Sohawel*, red marle underlies the *lime-stone* above-mentioned; at *Nagound*, in the bed of the *Omeron* river, its lower and central beds are exposed to view, containing fragments of fossil wood, also fragments of stems of ferns, and one piece exhibited, what I took for an impression of the gryphite shell, which is peculiar to this formation; at *Marhar*, near the tank of the old village, it reposes on red marle, in conformable stratification; and at *Lohargong*, the wells of the cantonments exhibit its upper or slaty beds, reposing upon smoky grey *lime-stone*.

From *Lohargong*, I proceeded, via *Mehewa*, *Ghysabad*, *Hattah*, *Narsinhgerh*, and *Patteríya*, to *Ságar*.

The first part of the route, was over an alternating succession of *lime-stone* lowlands, and *sand-stone* collines, which continued as far as the *Kén* river, the bed of which is red *marle* and *stand-stone;* afterwards, the same alternation occurred to *Hattah*, where the *lime-stone* reposes on red *marle*, in the banks of the *Sonar* river, as it does also at *Narsinhgerh*, in a small ravine north of the fort; but there the *marle* is almost entirely *green*. At *Patteríya*, it comes in contact with *trap* rocks, and is thereby changed both in appearance and nature; those portions which contained most *silex*, are converted into *chert*, and it is curious to see specimens, one half of which is *chert*, and the other half still retaining the property of effervescing with acids.

The general aspect of this *lime-stone* is dull and earthy; its stratification is horizontal, or nearly so, and always conformable to the *marle* or *sand-stone* on which it reposes; its lower beds are thin, and separated by argillaceous partings; and some portions of it, particularly the white variety, are sufficiently compact for Lithographic purposes: the middle beds are usually of a dark smoky grey colour, always exhaling a strong argillaceous odour when breathed upon, and sometimes containing fragments of petrified wood, and of the stems of ferns, as may be seen at *Nagound;* and it is this variety which burns into strong *lime,* and has the property of hardening under water: the yellow kind is generally compact, usually dendritic, and if polished like the *Cottam* marble, might be used for ornamental architecture; its external surface frequently presents branches and prominences, resembling (as Mr. GREENOUGH expresses it) the interlacings of ivy, and in this state it might be used for rustic architecture.

This *lime-stone* appears to be the same as the *lias lime-stone* of England, and the specimens I send herewith, shewing its ordinary varieties, will enable the Society to judge how far my conclusions are well founded. It extends all over the platform of the second range of hills, covering it with a thin stratum, the continuity of which is only interrupted by occasional protrusions of the red *marle* or *sand-stone,* on which it reposes, and as these *sand-stone* collines are generally sterile, from want of soil to cover them, the *lias* formation becomes an object in agriculture, because it occupies the low lands, which retain moisture, and are covered with rich soil.

After passing the town of *Pattariya,* I came upon the overlying rocks, which I designate by the general term of *trap;* the hills on the left of the road are composed of those rocks, and after ascending the pass of *Patteriria,* I met with no other rock than *trap,* between it and *Ságar.*

The upper part of the *trap* of *Ságar*, like that of *Patteriya*, is frequently globular, the nuclei of the decaying masses varying in size from an egg, to a large bomb-shell; and their decomposing concentric lamellæ, being generally very thin, and often very numerous; the best specimens are too heavy to send, but that which accompanies this paper, will perhaps serve to explain my description.

Under the stratum of globular *trap* which usually occupies the highest part, is a bed of indurated *wacken*, or amorphous *trap*, of a rusty brown colour; sometimes scoriform, or of a small cavernous structure, and sometimes columnar; but this last form I have only observed in the beds of streams, or on the borders of the formation; under the amorphous *trap* is a stratum of *lime-stone*, white as chalk, which is observable at *Ságar*, and in the hills near *Pattaríya*.

I have termed this white rock earthy *lime-stone*, because I know not what other name to give it; its principal component is carbonate of *lime*, and next to that is *alumine;* it also contains *silex* and when it abounds, the rock is converted into *chert: felspar* does not seem to be abundant, and though the rock occasionally assumes the texture of indurated *clay*, and sometimes, though very rarely, the hardness of *clink-stone*, yet, generally speaking, it appears as if partially calcined, and when the *trap* with which it is associated reposes on *sand-stone*, as is the case in the district of *Ságar*. it contains nodules of *sand-stone* imbedded in it; the accompanying specimens exhibit its most ordinary changes above the surface; but several wells have been dug at *Ságar*, and its changes below the surface are shewn in a second series, sent herewith, one of which appears to be almost pure *alumine;* a thin *jaspery* stratum sometimes intervenes between the *wacken* and the *lime-stone*.

Below the *lime-stone* at *Ságar*, is a stratum of *amygdaloid*, containing *calc-spar*, and a few *zeolites*, which resembles the *toad-stone* of England; it there reposes on *sand-stone*, but I have not met with it in *situ* in any other part except some indistinct vestiges near *Jysinhnagar*, nor can I state, upon any authority, that the position here described, is applicable elsewhere.

From *Saugor*, I proceeded southward, via *Jysinhanagar* to *Tendukaira*, and met with no other rock than *trap* (with abundance of *chalcedony*, *semiopal*, mealy *zeolite*. *cacholong*, *agates*, *jaspers*, and *heliotrope* strewed upon it,) until I descended the range of hills which forms the northern barrier of the valley of the *Nermada* river.

This great valley is favourable for throwing light on the primitive rocks of the central chain, where the force of receding water appears to have swept away the upper, and exposed to view the lower and older strata; many inferences may hereafter be drawn from a careful examination of this valley, but it would be premature to hazard any conjecture at present. I will, therefore, only observe, that the whole mass of overlying rocks which I have just passed, reposes on red *marle*, or *sand-stone*, as is apparent in the bed of the *Barana* river, about one mile north-east of *Tèndukaira*, and all along the foot of the hills in that direction.

Its associate, the earthy *lime-stone*, here becomes a rock which generally appears half calcined; but its property of effervescing with acids is not destroyed, except in a few instances where it has become highly indurated; it fuses readily with a moderate heat, and operates as a flux when mixed with clay; and in this part, it almost always contains fragments of *sand-stone*, which are more or less changed by its contact.

After descending the hills, and advancing about three miles into the valley, a new field opens ; the older rocks are laid bare and exposed to view, and instead of horizontal stratification, they become highly inclined, sometimes perpendicular, and altogether unconformable to those which I have just passed; I shall not here mention the *iron mines of Tendukaira*, because a satisfactory account of them would swell this paper too much; but I will observe one circumstance which may, perhaps, be acceptable to travellers—the conical hill, situated about one mile and a half westward of *Tendukaira*, is an isolation of *trap*, and its summit was once crowned with a cluster of *basaltic* columns of a greyish green colour; but some violent effort of nature, such as an earthquake, has dislocated them, and they now, even in their ruins, present an object worthy of the notice of a traveller.

From *Tendukaira*, I made a detour to *Garha Kota*, to meet the Agent of the Governor General, and my route thither enabled me to lay down the eastern boundary of the *trap* formation ; a reference to the map, therefore, will best explain the result of this part of my route. I always found the *trap* in association with earthy *lime-stone*, and the whole series reposing upon red *marle*, or *sand-stone*.

From *Garha Kota*, I returned to Great *Deori*, and proceeded across the *Bandair* hills to *Jebelpur*.

After quitting *Deori*, the rock was *trap* for about three miles, and then commenced the *sand-stone* of the *Bandair* hills, which continued uninterrupted, until I descended the eastern escarpment of those hills, which again brought me into the valley of the *Nermada* river.

The *sand-stone* of the *Bandair* hills, is mottled (red, speckled with white spots or streaks), its stratification is horizontal as far as the eye can judge, and it appears to correspond with the *bunter sand-stein* of WERNER, and, consequently, with the new red *sand-stone* of England; the same hills are composed of the same *sand-stone*, opposite to *Nagound*, *Lohargaon*, *Tigra*, and *Ghysabad*, and there can be no doubt that the whole is a mass of the same kind of *sand-stone*, varying, perhaps, in appearance, but not in character; and it would be interesting to examine whether there are any traces of an *oolitic* formation on their summits.

After proceeding about three miles into the valley, I came upon the ridge of the *Kymur* range of hills, which here begins to break, and soon disappears below the surface; in this part it is composed of silicious *grit-stone*, which evidently passes under the sandstone of the *Bandair* hills, but to the south-west of this point, near *Hirapur*, the rock becomes more compact, and still further west, opposite *Gúgri*, it is intermixed with *schistose* limestone, which contains *mica*, and, perhaps, green *talc*.

Between this range and *Jebelpur*, is a broad valley, covered by a thick stratum of *alluvium*, which required much more minute investigation than my hurried route enabled me to bestow

The town of *Jebelpur* is situated at the foot of a range of *granite* hills, which, perhaps, might be termed *syenitic granite*, as its composition is flesh-coloured *felspar*, smoky *quartz*, a little black *mica*, and much *horn-blende*. I have traced it for thirty miles, in which space it dips below, and rises above the surface several times, and there the rock becomes well defined *granite*, and is particularized by its tendency to exhibit *logging-stones*: it is much subject to decomposition, from the quantity of *felspar* it contains.

Every formation subordinate to *granite* is to be found in this neighbourhood Gneiss, containing *hornblende*, and partially decomposed, so as to acquire a *ligniform* appearance, is in the bed of the *Nermada* river, at *Tilwara* Ghat; *Mica-schist* is at *Ramnagar*, and all along the low range of hills, which runs from thence towards *Lamaita*. *Hornblende-schist* is in the hills, between the villages of *Bhowra* and *Pareri; talcose*, and *argillaceous-schists* in the hills between *Bhowra* and *Maroud*, and in the bed of the river between *Lamaita* and *Beragarh*, a series of strata are laid bare. exhibiting *gneiss* at one extremity, and from it, a regular gradation of *micaceous* and *argillaceous-schists, to* schistose limestone, *quartz-rock*, and the beautiful snow-white *dolomite*, which is described in the following paragraph. I cannot here omit to recommend to any traveller, desirous of observing these strata, to walk along the edge of the river from *Lamaita*, to the water-fall of *Beragarh*, from whence he may either proceed in a canoe, through a narrow channel, excavated by the torrent, and enjoy a spectacle, far exceeding any description I can give of it, or he may return by the ruins of *Tripurapuri*, which are near the village of *Teor*, and examine the remains of the ancient capital of *Garha Mandela*.

The *Dolomite* is near the water fall; it has been called *muriacite* and *alabaster*, both of which it resembles; but from its geological connections, as well as its composition, it is evidently a *dolomite*, and its most refractory portions, if pulverized, will effervesce, with diluted *nitric*, or *muriatic acid;* a few miles further west, it effervesces freely, and is friable, almost crumbling between the fingers, and contains crystals of *Tremolithe;* but at *Beragarh*, being intimately associated with *quartz-rock*, it contains more or less *silex*, and the snow-white variety, which resembles *alabaster*, seems to be an aggregate of *dolomite* and pure *quartz:* this variety scarcely effervesces without being pulverized, but it takes a fine polish, and is quarried for various purposes, such as slabs for floors, or tables, and it might well be used for ornamental architecture, or even for statuary: it is traversed, in many parts, by veins of *chlorite schist*.

From *Jebelpur*, I returned to *Tendukaira*, by another route along the metalliferous range of hills, which it was my business to examine; but I refrain from giving any account of its mines, for the same reason which I have alledged in my account of *Tendukaira*. I must also defer sending a map of this portion, which I have constructed on a larger scale, in order to shew the position of the mines, until a future opportunity; in the mean time, I may observe, that a part of the southern barrier of the valley of the *Nermada* river (like the northern, opposite to *Tendukaira*, *Sírmow*, &c.) is composed of *trap* rocks, the contour of which I have laid down to the extent of eighty miles, and I trust, that a future opportunity will enable me to complete the whole.

The result of my inquiries respecting this eastern deposite of overlying rocks, is, that it extends southward, as far as *Chaparah*, or *Seoní*, and thence eastward, towards *Mandela*, *Amerakantak*, and *Sohagpur*; but whether it unites with the great central mass, I could not learn; it is somewhat harder than the *trap* of *Ságur*, but does not essentially differ from it in character, as the accompanying specimens will shew; but it differs greatly in its substratum, which is here *granite* or *gneiss*.

In the re-entering angles of the *trap* hills, the occasional re-appearance of the primitive range may be traced, and in a cluster of such hills, about one mile south of *Bograi*, the rock is composed of *mica*, *quartz*, compact *felspar*, and *chlorite*, intimately intermixed in fine grains, and somewhat friable; in the same hills also, is a conglomerate of the same formation, containing *quartz - pebbles*, much rounded, and worn by the attrition of water, but no fragments of *green-stone* or *basalt*, although the hills in question are nearly surrounded by rocks of the *trap* family.

After passing *Bograi* the valley expands, and is covered by thick alluvium, through which the *dolomite* occasionally crops out for a short distance; but with that exception, no rocks appeared above the surface, until I arrived at *Kshirarpani*, where the hills are composed of stratified *quartz* rock, sometimes granular, but more frequently compact, and containing *felspar*, the strata are highly inclined, and sometimes perpendicular, and as there is no other kind of rock, between *Kshirarpani* and *Tendukaira*, except the isolated sandstone hill of *Amjero:* this brings me back to the *sand-stone* and *trap* formation of the *Ságar* district.

To this catalogue may be added a very curious calcareous conglomerate, which is found in the beds of most rivers, whose sources, or whose channels are in *trap* countries; I have observed it in the bed of the *Sonar* river, north of *Reili*, and in other places; it occurs also plentifully in the *Nermada* river in various parts; but the largest mass I have seen of it, is near the *Jansi* Ghat.

It is composed of rounded fragments of *wacken*, *basalt*, sandstone, *quartz*, and occasionally of other rocks, varying from the size of a pea, to that of an ordinary grain of sand, cemented by calcareous matter, and when the particles are fine, the rock in some respects resembles calcareous *sand-stone*, and has sufficient cohesion for architectural purposes; its stratification is always horizontal, the coarse parts being lowest, and it reposes on the subjacent stratum, be the rock what it may, for it is evidently the latest formation; thus at *Beragarh* it may be seen in the high banks of the river, reposing upon the primitive strata, and itself covered only by alluvium to the depth of thirty feet.

I have not met with a description of this rock by any author, and yet it cannot be considered strictly local, for it is evidently a conglomerate, formed from the detritus of *sand-stone*, and overlying rocks, which appear to be its chief constituents, and, consequently, must be of considerable extent in this country.

Having thus given a description of my route, and a brief compendium of my observations as they were made on the spot, I will now venture a few general remarks on the conclusions I have drawn from them and should I inadvertently lean to either side of a disputable question, I intreat that it may not be attributed to design : I am not learned enough in the science to become an advocate for any party : a few lessons when in England, and the great volume of nature have been my chief guide, and to record facts, to lay down strata correctly, though not minutely on a map, to extract that which is useful or profitable in the science, is all I aim at, and the train of investigation which this requires, imperceptibly leads to an acquaintance with books, which gives facility of discrimination and description, even though the depth of the science may be wanting.

The late Dr. VOYSEY observed, " that he had reason to believe, partly from personal observation, and partly from specimens obtained from other sources, that the basis of the whole peninsula of India is *granite:* he had traced it along the coast of *Coromandel*, lying under *iron-clay ;* also in the bed of the *Godaveri* river, from *Rájamahendri* to *Nandair*, and he had specimens from the base of the *Śítábaldi* hills of *Nagpur*, from *Travankur*, *Tinnevelli*, *Salem*, and *Bellari;*" to this may be added Mr. STIRLING's account in his memoir on *Cuttack*, where he says, " the *granite*, where my specimens were principally collected, appears to burst through an immense bed of *laterite (iron-clay,)* rising abruptly at a considerable angle." These are recorded facts on the southern side of the central chain, and on the northern side, it may be observed, that the plains of *Bundelkhand*, attest that *granite* is there the basis rock.

Though I am convinced that *granite* is very near the surface, in many parts of the tract which has fallen under my observation, yet it is evident, that there is a series of primary stratified rocks, intervening between it and the secondary formations, as in other parts of the world, though there is reason to think that they are often wanting; the flanks of primitive ranges of hills almost always exhibit a series of these rocks, and as an instance, I refer to that which is laid bare in the bed of the *Nermada* river, between *Lamaita* and *Beragarh*, these strata are not intermixed, they present a series of beds from *gneiss* upwards, each in its place, graduating one into another imperceptibly, and all preserving the same dip, direction, and parallelism, without any tendency to derange each other, and they are found on the spot, where the river intersects the primitive range of *Jebelpur*.

In this part of India, however, the primary formations are so extensively covered by secondary and overlying rocks, that vallies of denudation alone expose them to view; and under that impression I observed in a former paragraph;· that many inferences may hereafter be drawn from a careful examination of the valley of the *Nermada* river, and I may also add, from a careful examination of all great vallies of denudation, which, like that of the *Nermada* river, exhibit a view of the primary strata, by removing the superincumbent beds under which they were buried.

The *sand-stone* formation is the next which attracts notice; its thickness is, of course, variable, it is four hundred and twenty feet, at the *Bouti* cataract; and from the compactness of the rock, at the bottom of that water-fall, I am disposed to think that it does not extend far below; there can be no doubt, however, that it is thicker near the *Chachai* and *Tons* cascades, and the *Bandair* hills must be still more so; it appears to comprize most of the varieties of Dr. MACCULLOCH's synopses of lowest and some of his superior *sand-stones*, whilst the general parallelism of its stratification to the horizon, and its saliferous nature, well enough identify it with the new red *sand-stone* of England, which comprises all those beds that lie between *lias lime-stone* and the coal measures.

The *lias lime-stone* formation is exceedingly curious, for, whilst in other countries it forms mountainous tracts, and occupies extensive portions of the earth's surface, it is here a mere plastering over the surface of red *marle* or *sand-stone*, and I should doubt whether it ever attains the thickness of a hundred feet. I have not met with it in any other place than on the summit of the second range of hills, and it may there be seen in the low lands, and in the beds of small rivulets, but in the large rivers it appears to have been swept away, as their channels are worn down to the subjacent sand-stone, and perhaps, in some cases, to the primitive strata.

The overlying *rocks* of the *Ságar* district appear to be the flœtz-trap of WERNER; they are not only the most extensive, but, considered as *geological phænomena*; they are the most important in that district, and, perhaps, in India. The prevalence of opinion regarding their origin is now, indeed, inclining to a modified volcanic theory, and as their extent is truly astonishing, I feel persuaded, when their correct outline shall have been ascertained, that the representation alone will be correspondently striking. As far as my observations have extended, I have never been able to reconcile my ideas of it, to the *Wernerian* theory alone; I have seen it meandering round isolations of *sand-stone*, and resting against them in a manner which could not have occurred, had its origin been such as is described in that theory, without covering the *sand-stone* also. Its known effects on other rocks, which come in contact with it, are also striking circumstances; but as India possesses advantages over all other countries in the investigation of this subject, it would be premature indeed to draw inferences before we are in possession of the facts, which alone will enable us to arrive at a satisfactory conclusion. The thickness of this formation we have it not in our power to obtain, as it is constantly variable; in the centre of India, it occupies the summits of the highest mountains, and at *Bombay*, it descends to the level of the sea; it reposes indiscriminately upon every rock, from *granite* upwards, and it is quite impossible to fix on any average: it is useful, however, to find out the rock on which it reposes, and its inferior level in the tract under examination; thus, for instance, at *Ságar*, it reposes on *sand-stone*, and its inferior line, in that district, is about 1350 feet above the sea, and as this is also the superior limit of *lias*, it follows, that the *trap* of *Ságar* is unequivocally posterior to *sand-stone*, and may be either *just* previous to, or contemporaneous with, or posterior to *lias*, the latter of which, I apprehend, will be found to be the case.

There are two kinds of *basaltic* rocks in the district of *Jebelpur*, which are clearly distinct formations; the oldest variety is that which penetrates the *graywacke* stratum in the bed of the *Nermada* river, near the village of *Lamaita*. This stratum, though not above fifty yards thick, is intersected by innumerable *green-stone veins* and *nodules*, always running in the direction of the strata, and as they do not occur in any of the adjoining formations, they must, I presume, be at least as old as that rock; the other *basalt* is an overlying rock, like that of *Ságar*, but it reposes on *granite* or *gneiss*, instead of *sand-stone*, and appears to contain a greater proportion of *augite*.

The calcareous conglomerate must be classed, in point of time, at least with the *tufas*, and other calcareous formations, such as common *kankar*, so prevalent in India: it is generally admitted, that these substances have been deposited from water, in rapid motion, holding the matter in solution, and under circumstances unfavourable both to crystalization and regular deposition, and it has sometimes occurred to me, that the matter of which they are composed, may, in other countries, under more favourable circumstances, have been deposited in regular beds and strata, such as the *oolitic* formation of England; and I am the more inclined to think so, from finding the *lias* stratum so thin; also from its upper *slaty* beds being in general wanting; and further, from not having hitherto discovered any traces of a regular *oolitic*, or any later regular formation.

The great extent of *trap* rocks, being nearly equal to a third of the area of the country, and the absence of all regular formations posterior to *lias*, if future research should prove it to be the case, are undoubtedly remarkable features in the geology of India; and I cannot help thinking that they may, hereafter, be the means of explaining some of the most important phœnomena in the science, provided the facts of the case are well and justly ascertained.

Barometrical observations made on the route from *Mirzapur* to *Ságar*, and thence to *Tendukaira*, and *Jebelpur*, with heights above the sea deduced therefrom, together with the Latitudes and Longitudes of the respective places.

DATE.	PLACE.	BAR.	THER.	HEIGHT.	LATITUDE NORTH.			LONGITUDE EAST.		
					°	'	"	°	'	"
1826										
November.. 24	Lalganj, ...	29 56	69	504 feet	24	1	25	82	18	25
25	Barounda, ...	......	....	.. ..	24	57	20	82	14	00
26	Kattra, ...	29 57	70	520 feet	24	52	20	82	6	30
27	Hanmanna, ...	28 79	68	1219 „	24	46	15	82	4	15
28	Bilohi fall, ...	28 69	68	1128 „	24	48	45	81	57	15
29	Bouti fall, ...	29 04	71	1000 „	24	46	40	81	49	20
30	Gerh, ...	29 00	71	1036 „	24	49	15	81	39	50
December 1 & 2	Keuti fall, ...	29 12	70	923 „	24	49	15	81	27	00
3	Chachai fall, ...	29 05	70	990 „	24	48	0	81	17	20
„	Tons fall, deduced from the same, ..	. ....	....	890 „	24	47	15	81	15	05
4	Simeriah, ...	29 01	72	1009 „	24	48	34	81	8	55
5	Birsinhpur, ...	29 00	76	1064 „	24	48	30	80	57	20
6	Hathi, ...	28 99	74	1070 „	24	43	18	80	49	15
7	Sohawel,......... .	29 00	73	1059 „	24	34	27	80	46	40
8	Nagound, ...	28 97	75	1099 „	24	34	21	80	35	25
9	Girwar, ...	28 85	77	1216 „	24	33	0	80	25	30
10	Lohargaon,........ .	28 80	75	1251 „	24	31	15	80	19	00
„	Ditto above Calcutta, .	......	....	1231 „						
11	Mehewa, ...	28 86	72	1181 „	24	24	20	80	7	25
12	Tigra, ...	28 94	70	1093 „	24	18	20	79	59	05
13	Garreho, ...	28 90	71	1131 „	24	15	38	79	49	35
14	Hatta, ...	28 86	74	1183 „	24	7	45	79	35	10
15	Narsinhgerh,........	28 71	72	1314 „	24	1	08	79	24	20
16	Bikairi, ...	28 76	70	1263 „	23	52	02	79	13	10
17	Saipur, ...	28 57	70	1442 „	23	53	15	79	2	30
18	Pareneah, ...	28 34	68	1644 „	23	51	30	78	56	10
19 to 31	Ságar, (tent)	28 10	77	1933 „						
	Ditto above Calcutta, .	......	....	1926 „						
	Ditto Town, ...	......	....	1940 „	23	50	30	78	44	00
	Ditto Cantonments, ..	......	....	1980 „						
	Ditto Residency, ...	......	....	2050 „						

Date.	Place.	Bar.		Ther.	Height.		Latitude North.			Longitude East.		
1827							°	′	″	°	′	″
January 4	Jysinhnagar, ...	28	00	60	1943	feet	23	37	12	78	33	30
Morning 5	Garreah, ...	27	90	71	2094	„	23	30	17	78	39	00
Evening 5	Tandah, ...	28	10	61	1851	„	23	23	37	78	41	40
January 6	Ghano, ...	28	30	74	1724	„	23	22	55	78	49	45
Evening 6	Sehajpur, ...	28	50	71	1515	„	23	17	50	78	53	30
7 to 10	Tendukaira, ...	28	70	75	1338	„	23	10	40	78	58	30
19	Debí, ...	28	32	75	1704	„	23	17	12	79	04	55
21	Gt. Deori, ...	28	30	70	1705	„	23	24	18	79	04	50
22	Chandpur, ...	28	45	71	1575	„	23	34	21	79	06	15
23 to 24	Gara Kota, ...	28	66	67	1345	„	23	47	25	79	07	30
25	Reilli, ...	28	60	66	1350	„	23	38	50	79	03	45
26	Rangir, ...	28	47	66	1522	„	23	37	45	78	55	20
27	Chandpur, vide above,											
28	Gt. Deori, vide above,											
29	Kúsiari, ...	28	47	79	1584	„	23	23	48	79	11	55
31	Bynsa, ...	28	67	81	1394	„	23	24	38	79	20	00
February .. 1	Samnapur, ...	28	51	79	1546	„	23	19	45	79	25	00
2	Patteriah, ...	28	67	81	1395	„	23	15	35	79	34	45
3	Natwara, ...	28	65	84	1426	„	23	10	30	79	40	20
4 to 10	Teor, ...	28	64	75	1396	„	23	09	20	79	51	45
12 to 18	Jebelpur, ...	28	60	81	1458	„	23	10	40	79	58	15
	Ditto Cantonments, ..	.....		. .	1470	„						
	Ditto Residency, ...	..		...	1500	„						
19 to 20	Pannagerh, ...	28	58	80	1477	„	23	19	15	80	02	30
21 to 22	Pouri, ...	28	62	76	1423	„	23	23	00	80	08	50
23 to 24	Majgowa, ...	28	52	84	1550	„	23	21	15	80	14	30

Note.—From the 24th of February, and throughout the whole of the month of March, and part of April the weather was very unsettled, raining at intervals, and this unsettled state was followed by great heat in May and June, which became excessive in the beginning of July. The Thermometer at Tendukaira ranging from 120° to 122° in the sun, and from 108° to 110° in the shade, which rendered Barometrical observations for height, too uncertain to be relied upon.

APPENDIX.

APPENDIX.

THE barometrical observations of the accompanying table were in every case, not particularised, derived from a mean of several during the day, and sometimes as at *Ságar*, *Tendukaira*, and *Jebelpur*, from a mean of several days; the mercury of the barometer was taken out, the tube cleaned, and fresh mercury purified by Mr. Prinsep, of *Benares*, substituted at that place; after which it was compared with his barometer, and as a check upon it, I used a box barometer of Sir H. Englefield.

It was constantly hung up in my tent, and the detached thermometer suspended in the shade in the open air, and I always waited, until the attached thermometer agreed with that which was detached, or in other words, until the quicksilver of the barometer had acquired the temperature of the air; so that one thermometer was sufficient to register.

My method of calculation is that of Dr. Hutton, checked, indeed, by that of Dr. Robinson, but never altered, because the results were nearly equal, and my point of reference and comparison was a station of the grand trigonometrical survey at *Ságar*, which is 2195 feet above the level of the sea.

I ascertained by measuring a base line, that this station was 250 feet higher than the tent where my barometer was placed, and a mean of fourteen observations gave 1933 feet for its elevation above the sea according to Dr. Hutton's method, 1933+250=2183, differing only twelve feet from the geometrical result; and as I have used the same barometer and the same mode of calculation throughout—if twelve feet be added to each of the items of the table, they will, I conclude, be nearer the truth, because I have greater confidence in the geometrical results, than in those of the barometer.

The stations of the trigonometrical survey, afford an excellent opportunity of comparison and check, and provided they are referred to at moderate intervals, it matters but little what formula of calculation is used, if it is constantly the same, as the results cannot greatly vary, if the barometer is also the same, and the observations are carefully made.

The average height of the first range of hills between *Túra* pass and *Kattra* pass is about 520 feet above the sea; that of the second range, between the *Kattra* pass and *Lohargaon*, 1050, and between *Lohargaon* and the foot of the hills near *Patteriya*, about 1200 feet, gradually ascending.

The average height of the highest parts of the third range, or *Bandair* hills, ascertained geometrically from *Lohargaon*, *Tigra*, and *Garreho*, is about 1700 feet, and as they are the same, deduced barometrically at *Samaspur* and *Patteriya*, they are evidently a platform, like the first and second ranges, varying only from a perfect level by the undulations described in the account of them.

The junction of the *Sonar*, *Bearmi*, and *Kén* rivers, is about 1000 feet, ascertained from *Tigra* and *Garreho*; the source of the *Sonar*, is 1950 feet, and its fall 950 feet in a course of 110 miles; the source of the *Bearmi*, about 1700 feet, ascertained from *Samaspore*, and its fall to its junction with the *Kén*, 700 feet in 105 miles; the source and fall of the *Kén* river is nearly the same as the *Bearmi*, though its course to the point of junction is only seventy miles, but there is a cascade in this river at the *Piperiya* Ghat.

The highest line of *lias limestone*, is about 1350 feet, and the lowest near *Hat,hi*, about 1070. The lowest level of *trap* in the *Ságar* district, is near *Patteriya*, about 1350 feet, and its highest is the summit of the highest hills; of *sand-stone*, the highest level is in the vicinity of *Ságar* or *Raisen*, and its lowest the foot of the *Tára* pass; but these local levels have reference only to the tract which has fallen under my observations, and by no means apply generally.

The cantonments of *Lohargaon*, are about 1260 feet, those of *Ságar*, about 1980 feet, and those of *Jebelpur*, about 1470. The Residency of *Jebelpur*, is about 1500, and that of *Sagar*, about 2050 feet above the sea.

The latitudes have all been observed by myself, chiefly from meridional altitudes of the sun, when available, and when not, from observations of the stars, taken with a good sextant, by the method of reflection; the longitudes are from a large map of my own survey.

With regard to the geological map, having previously surveyed a great portion of the *tract*, I may, with some confidence affirm, that the topographical features are accurate, and so also are the outline delineations of *trap* and *sand-stone;* the *lias* required a more minute survey than my time afforded; the outline of its extent is correct enough, but the *sand-stone* collines, which protrude through it are, in a great measure, conjectural; and the primitive strata are comprised under one distinctive colour, as it would have required miniature minuteness to have delineated them, under separate heads; the strata of *Beragerh*, for instance, comprise a series from *gneiss* to *dolomite* in a space of two miles, and a delineation of them would have represented a ribband, with all the colours of the rainbow, rather than a geological arrangement, in a map of so small a scale.

III.

III.

THE TRAP FORMATION
OF THE
SAGAR DISTRICT,

And of those Districts Westward of it, as far as Bhopalpur, on the Banks of the River Newas. in Omatwara.

BY CAPTAIN S. COULTHARD.
Of the Bengal Artillery.

A GENERAL idea of the number of sand-stone hills, rising through the trap formation of the district about to be described, may be formed from the number of villages; for, although a few villages may be seen, situated on the slopes of trap hills, the natives, as far as possible, have avoided placing their habitations on rocks of this formation, and there being fully as many sand-stone hills, without villages, as trap with them, it may safely be said, that there are as many isolated patches of sand-stone in these districts, as there are villages.

At *Panchamnagar* and *Satpárah,* places marked in the accompanying sketch, there is the lias, and about nine miles west of those places, or at *Sanwa,* the trap and sand-stone. The same may be said of *Pattariya* and *Garakota*, on the right hand, and *Shahpur*, one march on the left, or westward; and then, if a line be drawn between these places as respectively mentioned, leaving the nameless rivulet as it occurs between *Shahpur* and *Pattaríya*, in the lias, and also continue this line southward to the red sand-stone hill, which overhangs *Tendukaira*, in the vale of the *Deorí*, there will be a tolerably correct eastern boundary given to the trap formation of *Ságar*.

The vale of the *Deorí* is of an older formation, than either the lias of the *Hattah* district, or the sand-stone subjacent to the trap of *Ságar*.

That red rock, which has been alluded to as skirting the *Deorí*, near *Tendukaira*, has its accompanying trap hills, and these, in their general direction, bend their course to *Hasanabad;* indeed at *Sírmow*, or soon after passing south of that place, the road from *Ságar* to *Hasanabad*, descends this trap range, and afterwards continues at their feet, on the south side, the whole distance to *Hasanabad*. Let it be added to his, that the road for fifteen miles south of *Hasanabad*, or as far as *Petraotah*, is on the alluvial matter of the *Nermada*, a deep black basaltic mould, and that at *Petraotah*, a hilly country again occurs, consisting of primary rocks, contingent on the granite of *Shahpur*, *Nímpání*, and *Bitúl*, and then there is a definite bounding line on the south.

If the cantonment of *Bhopalpur*, on the right bank of the river *Newas*, be taken as a point, and a line be drawn from that point to the *Nermada*, so as to pass between *Sultanpur* and *Dewas*, such line will cut through the eastern part of the trap formation, described by Captain LANGERFIELD, as that officer marks both those places in his sketch; indeed, that which is under description by me, is a mere continuation to the eastward of the newest floetz trap formation, named by that officer, as occurring in the upper plains of *Malwa*, or to speak still more correctly as to direction, it is a shoot up north-eastward from it.

With regard to the northern line of demarcation, I cannot be so satisfactory and clear. If a line be drawn from *Bhopalpur* to *Seronj*, it will pass through the formation. under review, but as to how far this formation extends north of such a line, I have no precise information. The *Maltoun* pass is of sand-stone, and I believe this rock ends somewhere between the crest of the pass and the village of *Naret*, not far removed from its northern foot. The granite is at *Tirí*. An iron ore is worked to a considerable extent at a spot intermediate between *Dhamúní* and *Marowra: Dhamúní* has the trap and sand-stone; and the trap ceases five miles and a half south of *Hírapur*, whilst the bare sand-stone, freed from any overlying mass, continues until it may be seen resting on matter incident to the primary rocks, at *Hírapur*, and where, too, it ceases entirely. Nearly in this direction will be the northern limit of the trap formation, as laid down in the accompanying sketch, but much confidence is not to be placed in it; the boundaries, however, to the east, west, and south, may be offered as sufficiently accurate.

It is eighty-four miles from *Bhopalpur* to *Bhilsa*, and seventy-two from *Bhilsa* to *Ságar*, and twenty more bring us to *Shahpur;* and this line, though not a straight line, is sufficient to give a general idea of longitudinal extent. *Hírapur*, in the northern quarter, cannot be less than seventy miles distant from the southern boundary, given to the sketch; and the whole of this extensive area is occupied by the newest flœtz trap formation of WERNER, subjacent to which is the new red sand-stone, shooting up frequently from below through the overlying rock.

It is a hilly tract throughout; but it may be better understood if it be said, that at *Ságar*, in its neighbourhood for eight or ten miles around, and also in every part south of *Ságar*, within the prescribed limits, and as far west as *Hasanabad*, may be seen ranges of low hills extremely clustered, though always detached, bending about in their short course towards all points of the compass, and thus forming valleys of every conceivable form, though not commonly of any great extent, and never difficult of access. But if the view be extended beyond the neighbourhood of *Ságar*, towards the east, or the west, or the north, expanded valleys will gradually meet the eye, whilst the hills recede from it sinking in the horizon as they surround valleys farther removed from *Ságar*, until these valleys are enlarged into extensive undulating plains, studded over with isolated trap hills, occasionally of a conical, commonly of no determinate form, whilst ever and anon, a short range of the same, deviating little from a straight line, will have its beginning, and its ending, within view.

These valleys and these extended open plains, are every where composed, near the surface at least, of a trappean or basaltic mould, blackish in color, which reposes either on a bed of basalt, or on a bed of compact wacken. This compact basalt, or compact wacken, is either of an uniform ovate form, or else it is in angular pieces of middling size, and underneath these, as their occurrence may respectively be, lies an amygdaloid decomposing and decomposed, and which, as a retentive clay, keeps up the water near the surface, and it is so met with throughout this tract.

As to the trap hills, there is no occurrence of a bold bluff escarpment belonging to them, their sides and ends are always sloping and rounded, and, as far as the angle subtended from the summit is concerned, of easy ascent. Their surfaces are thickly strewed over with masses of basalt or wacken, imbedded in a basaltic or wacke clay, and differing only in size and form in different places, in a trifling degree. From one hundred and twenty to one hundred and fifty feet above the edge of the contiguous vale, may be said to be the general height of those that rise above the rank of swells and knolls, whilst a hummock, a cone, or something of a truncated cone, occurring in their otherwise even outline, and which serve to characterise them from their sand-stone companions, partially increases the elevation.

The sand-stone rock is very prevalent, as a mere mound or rise, constantly having a village upon it, and situated often on the plain ground, oftener on the edge of the plain ground, with a trap hill partly resting on it. In particular parts of the country, however, ranges of sand-stone hills occur, equalling, though never exceeding, in height and extent of range, those of the trap, whilst they are to be easily distinguished from them by their general evenness of outline; by their having vertical or precipitous escarpments at their ends, and on their sides to within twenty or thirty feet of the top; by the fallen masses lying about; by often sharply-defined, castellated, and mural appearances on their summits, and, in short, are to be distinguished by all that which has been remarked of them as exclusive, when occurring in other countries. They never appear inter-stratified with any other mineral, when they occur in the tract of country under review.

And these swells and hills of sand-stone and of trap, most particularly the former, may often be observed sterile and bare, shewing nothing but some coarse grass during the season of the rains, which gives to them, at that time, a tinge of green; but the vast majority of them are ever thickly cloathed with vegetation, consisting of plants, and shrubs, and forest trees of stunted growth, in particulars only differing from those of constant and every-where occurrence in India, and which have often been numbered and described. And lastly, the flat and compressed surfaces of both kinds of hill, are often of considerable breadth, and on the summits of the trap hills. not those of the sand-stone, more especially in the angular parts of the trap hills, as they bend about, may be seen a patch or cultivated spot.

With regard to the general level of this land above the sea, I may observe that there is a peak shooting up from a trap range to the eastward of *Raisen*, which attains an elevation of something more than 2500 feet; but the hills of *Raisen* are much less, so also is the sand-stone range of hills on the north bank of the *Nermadá* at *Hasanabad*. *Ságar*, upon the whole, is the highest part in this tract. The centre of the cantonments at *Ságar* is 1983 feet above the level of the sea by the barometer, and the hill at the mint of *Ságar*, which is about a mile from the last named point, is something more than 2300 feet by trigonometrical calculation. I have before remarked, that *Ságar* and its neighbourhood is a confined hilly tract, and that towards the east, and the west, and the north, the country opens; and it is, in fact, taking *Ságar* as a radiating point, in those directions that the land opens that the general elevation of it above the sea decreases;—but not so much westward or towards *Bhopalpur*, as the general elevation of the upper plains of *Malwa*, is 1650 feet, and *Omatwara*, in which *Bhopalpur* is situated, belongs to those plains;—neither is it so much towards the lower lias formation of the *Hattah* and *Garakota* district, or eastward, because the elevations there are, in general, about 1500 feet. It is in the northern quarters that the principal, and a rapid diminution in height is to be observed, for the *Maltoun* pass, nearly due north of *Ságar*, and six and thirty miles distant, is only 1000 feet above the level of the sea, by trigonometrical calculation;—*Seronj*, to the westward of north from the same place, is 800, and *Hirapur*, to the eastward of north, between 1000 and 1100 feet, by the same calculation. From all this it is to be inferred, that the elevation about the central point of *Ságar* is from 1800 to 2500 feet, and that in a northerly direction the land declines considerably,—and much more in that direction than it does towards the east or towards the west. In addition, if it be observed that the primitive range skirting the alluvium of the *Nermada*, south of *Hasanabad*, was found to be on a general equality as to heighth, with the trap and sand-stone rocks of *Ságar*, whilst the granite range of *Bundelkhand*, on the northern limits, is at least 1000 feet lower than those rocks of *Ságar*, a point nearly midway between the two-named primitive ranges, all is said, it is hoped, that need be, to assist the idea as to what is the general elevation above the level of the sea of the trap and sand-stone under review.

There exists so strong a family likeness between all the trap rocks of this formation, that it may safely be said, was chemical analysis resorted to, a nearly similar result would, in almost every case, be obtained. It is always every where an earthy homogeneous deposit, by which is to be inferred that there does not occur in it any rock of a definite, or nearly approaching to a definite, crystalline structure: neither a coarse-grained basalt will be found, nor a syenite, nor a green-stone, shewing distinctly its constituent simple minerals, nor is there indeed either a clink-stone or clay-stone. It appears as a closely allied family of basalts of a very fine grain, of wackens and amygdaloids, all others, of the long list of trappean rocks, may be thrown out of consideration, as of no alliance and of no occurrence here.

No. 1.—Of the few varieties there is one basalt which has been said* to be similar to the *Rowley Rag*, and it certainly does agree very closely with the description given of that mineral. Its colour is greyish-black, —its lustre is slightly glimmering, and it has a flat conchoidal fracture, and is difficultly frangible. It is not here the rock of most common occurrence, but I name it first, and marked it No. 1, because it is the hardest. It does not rise above the surface, but occurs in beds where the masses are of an uniform, egg-shaped figure, perhaps a foot and a half in their longest diameter, or it occurs in beds, where the masses are angular pieces, or cubes disfigured, not much exceeding a foot in measurement any way, and closely set together without cement.—It seems to be little liable to external decomposition, and its surface, which is smooth and entire, is coloured a yellowish white.

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* By Dr. Voysey, I believe.

No. 2.—There is another basalt differing little from the last, except that it has not the same tenacity, and its colour is soot black. It occurs only in angular pieces. I mark it No. 2.

No. 3.—Is another in colour like the last, but still softer, and which splits, with a moderate blow, at natural joints, into small four-sided prisms, coated with a blueish coating, like that often seen on newly wrought iron. —It is in the mass amorphous.

No. 4.—Is a five-sided prism. When the bed of a rivulet or river is composed of angular pieces of basalt or wacken set together in a pavement-like form, the surfaces exposed to the double effects of intense heat and moisture, will appear cracked into a variety of prismatic forms, and occasionally it will appear such as No. 4.

All these rocks seem to be, though not wholly, yet essentially composed of an intimate mixture of felspar and hornblende in an earthy state; and the latter, or hornblende, is the mineral that characterises all the harder kinds, whether compact or amygdaloidal, whether they are basalts or wackens, for their colour is black, or black only slightly modified :—The structure is always massive,—a laminated specimen could not be obtained.

But the principal rock, throughout this formation, is that represented by No. 5. It is what is termed a compact indurated wacken, in colour black, with a very distinct brownish tinge. When first fractured, its surface has a much more glimmering appearance, than the basalt, but unlike the basalt, exposure to the atmosphere, soon changes its surface into an earthy dirty whitish colour. It is often very tough, very refractory under the hammer, but its fracture is flat and dull,—not sharp and splintery, or approaching to the conchoidal. It occurs in pieces, in length, breadth, and depth, pretty nearly the same, a foot in measurement, and which are set closely together, so as to form something like a stratum in the hills,—or in the vallies as the base of the basaltic mould; and it is also the predominating variety in those hills, which are of such constant and general occurrence, consisting of large rounded and angular masses, thrown up together in the utmost confusion, with very little clayey matter intermixed;—and lastly, it may often be seen abstracted and alone, in something like large uniformly ovate masses, having a brownish and wrinkled exterior, and imbedded in a sombre reddish brown clay No. 5, is taken from a hill of the last kind.

No. 6 will exemplify the same where set as a stratum.

No. 7 is also the same kind of wacken, but it is decomposing with a nucleus of undecomposed black matter, and the superficial and decomposing part is a light yellowish brown;—further stages of decomposition might easily have been shewn to where the whole matter is changed to a greyish colour, and chips off into fragments like pieces of a small bomb-shell, or to where the whole mass is nothing but a soft easily workable clay, shewing however still the curved lamellar structure, and what it once must have been.

No. 8 has an aspect much resembling basalt properly so called, but its fracture is flat and sluggish.

A cellular, or honey-comb mass, will often occur intermixed with any of the foregoing,—the cells of which are externally empty, and internally filled with powdery whitish oxide of iron, which immediately falls out when the stone is fractured, such is No. 9.

No. 10 is wacken, with much olivine interspersed.

And No. 11 has something of green earth, and something of olivine in specks and splashes.

No. 12 has rather more of a blueish grey than a black caste, probably from the felspar rather exceeding its usual proportions.

It is much to be wished that the term basalt could be extended so as to include all those rocks named wackens for although there is some slight diversity of fracture and frangibility, and some little variation in colour, yet a difference in name seems quite uncalled for in regard to them and only calculated to mislead.—However thus much may be said, that those rocks in this list named basalt, are strictly compact,—no casual mineral will be found imbedded,—whereas the wackens on the other hand, whilst they are sufficiently compact to exclude any other term than compact, are seldom quite entirely so. An accidental mineral of the kinds incident to amygdaloids, may almost always be detected in them, and this too, together with the similarity of paste, serves to connect them with these amygdaloidal varieties, which, as elsewhere, in trap formations, here most commonly occupy the lower positions.

No. 13 is an amygdaloid which has been thought to resemble the toadstone of *England.* It has a black homogeneous paste containing chalcedonies, calcareous spar, and green earth. The former are often geodes coated externally with calcareous spar, and internally lined with minute crystals of quartz with calcareous spar filling up the cavity. Where green earth occurs in the same cell with siliceous crystals, the latter appear in a decaying state. The size of these imbedded portions do not, in general, exceed a nutmeg, although the chalcedonic geodes, &c. are sometimes a little elongated to the extent of three or four inches, and their sides are compressed.

No. 14 has the same paste as the former, though softer, and excepting green earth, has the same imbedded minerals; and when these are of a moderate and usual size, very pretty specimens of the whole rock are afforded, but in general this variety of amygdaloid envelopes very large sized portions;—a cylindrical geode of amethystine quartz was found measuring thirteen inches in length by two and a half inches in diameter. It was coated internally with beautiful quartz crystals, with calcareous spar, as stated in the previous specimen, filling up the cavity, and this mineral also coated the geode externally, and was seen much in splashes in the paste proximate to the cell. As regards these amygdaloids, it would seem in proportion as the contained mineral is large, so is the containing matter soft and friable, though still retaining its colour, a black, when fresh fractured.

No. 15.—Paste as before enveloping green earth, chalcedonics, and zeolites, the latter predominating.

No. 16.—Has a paste of a blueish grey colour, and appears almost completely saturated with calcareous spar; though much softer than any of those previously mentioned, it possesses greater induration than Nos. 17 and 18.

No. 19.—Is an amygdaloidal mass, consisting of innumerable pea-form nodules of calcareous spar, cemented together by a thin cement of basaltic or wacke clay of a light colour.

No. 20.—Is fully engrossed by minute crystals of zeolite, excluding from the paste any other mineral.

No other trap rocks, than those I have mentioned, are here of obvious and constant occurrence, at least if any other varieties exist I saw them not.—With regard to the simple minerals contained, calcareous spar is the most abundant, green earth, chalcedony, and quartz, are also very prevalent, but the zeolite minerals may be quoted as scarce. Well defined jasper is rarely seen, but something above an indulated clay, what may be termed semi-formed jasper, is of constant occurrence, so is hornstone; and both these last are to be found independant, but they are more generally lying contiguous to the limestone from which they are derived. The iron clay so easy to be met with every where, would hardly ever satisfy the mineralogist, for it is for the most part amygdaloidal, and not a simple mineral. It sometimes rises to the rank of a poor earthy red ore, and it is as such worked near *Barseah*, near *Raisen*, and at the source of the *Dasaon*, &c. Olivine throughout is every common,—but I have never procured either a crystal of hornblende or of augite.

But to the trap, not to the sandstone, belongs a hard white earthy limestone, harsh and gritty to the feel on the fresh fracture, and in which, rather sparingly, are imbedded small rounded particles of calcareous spar of a yellow colour. It belongs to the trap, and it is, moreover, ever attendant upon it throughout its range. Near the surface, or where it is in immediate conjunction with other matter, it may be found varying in colour and varying in the quantity of spathose matter. Very frequently, it will be of an ash colour, and the spathose particles, which are white and thickly set, forms the majority of the mass. Other specimens are reddish, brick red, deep chocolate, or brownish black;—others again might be produced, of which it would be difficult to say whether they were limestones or amygdaloids;—but always in proportion as it is coloured so is it the more clayey, gritty and impure,—more affected by foreign matter than that substance, which I have described, as the principal and characteristic rock.

This limestone rock is never found in the valleys, it is confined to the hills, and low swells, and generally forms the basement stratum in them, ascending somewhat above the level of the contiguous valleys. A stratum of this kind, is always sufficiently obvious in a hill possessing it; for along its sides, or at the ends, either a white patch mouldering by the weather immediately catches the eye,—or large rolled and angular pieces stand about, of a greyish colour, and very discernible from the blacker trap; though the continual line of the stratum, where it juts out to day, is not easily to be distinguished, the knobs, and exposed parts being generally covered with a blackish crust, and also intermixed with masses of indurated trap, and other more earthy matter, debris of the same, slid down from above. A white patch of this limestone, mouldering by the weather, is the source, from whence comes the particles of *kanker*, found intermixed with the black basaltic earth of the neighbouring valley, in such proportion, as to add increased fertility to it; and if a rivulet meanders through that valley, and such is generally the fact, patches made up of aggregated particles of the same, will here and there be found, and this it is which the native families pick out and work into lime. Where the grey coloured, large, rolled, and angular masses occur, there it is that a hornstone and jasper is to be found, though not both together in the same spot. The introduction of silica is of course the cause of the wholeness, and induration of those masses, which easily effervesce, but endless gradations are to be seen between these, and the two other minerals just named. If indurated clay, and semi-formed jasper are the derivations, the colour of these will, for the most part, be deep yellow; if green earth is the constituent of a neighbouring amygdaloid, the specimens will offer two colours, green and yellow, or yellow freckled with green. The hornstone varies much, from deep chocolate to straw yellow, from flesh coloured to nearly white. The flesh coloured hornstone, or chert, and the specimens shewing the lime-stone passing into this flesh coloured hornstone, or chert, found at *Bapyle*, about seven miles westward of *Ságar*, resemble exactly the same substances brought from the lias of the *Hattah* district, or eastward of *Ságar*; and this, together with the yellow fragments of lime-stone, of a tooth-like form, and somewhat dendritic aspect, also found at *Bapyle*, as well as elsewhere, is the fact that has much tended to increase the idea that the lime-stone of the trap of *Ságar*, and districts adjacent, is the lower lias half calcined, and disguised by the trap.

Some specimens of that which I have called the characteristic lime-stone will not effervesce at all, whilst others do so, but very weakly; but still oftener the acids take effect with sufficient briskness. Often the stratum of lime-stone is broader than the trap, which reposes upon it, and upon the mounds, and swells of lime-stone at the foot of the hills, occasionally will be found, a spot solely occupied by innumerable small fragments of spathose matter. These fragments are of a striated and radiated structure, and appear as if they had been purposely broken by the hand, and clustered together to the exclusion of any other matter ; however, it must be added, that some specimens of this species of spath are seldom wanting wherever the lime-stone rises to day, indeed the crystalized matter of this formation, when not imbedded in other substances, seems mostly to present itself with either a fibrous, striated, or radiated structure, and it is in its nature not pure and translucent.

A calcareous cement in these trap vallies, and near a streamlet, is often found forming trap tuff, that is, found uniting small *pisi-form* specimens of all the rocks, incident to this tract, into a mass, or bed of sometimes considerable induration, the surface of which will attract the eye by its rusty iron brown aspect, and its sterility.

It remains for me to describe the sand-stone underlying the trap, and so very often rising up through it, in the shape of hills, and swells. It is in no instance, that I have seen, interstratified with any other rock. Red marl, or clay, is sometimes to be seen alternating with it, in thin streaks, resembling the same rock under the lias of *Hutta*, &c. Galls of clay, or lithomarge, may frequently be found imbedded ; and as to its colors what elsewhere has been said of the same rocks in this regard occurs here, namely, they vary from a dark chesnut or chocolate, through red, reddish and salmon coloured, to nearly white and white. Massive kinds often shew two colors,—seldom more than two, and these two colors are a greyish white, and a deep chocolate, or it is a deep chocolate speckled with white spots. The slaty varieties, on the other hand, are exhibited clouded, streaked transverse to the structure, zoned, green, brown, red, ochre yellow, orange yellow, &c. &c., are, in fact, seldom exhibited, otherwise than with much diversity of shade and color, except perhaps a green variety. These slaty kinds are extremely micaceous, and the colors in the streaked varieties above alluded to, change at the line of cleavage ; and lastly, the eye never perceives any inclination worth mentioning, or variation from the horizontal position, either where viewed in the whole alluding to their general air and look, or when viewed in any part as regards the constituent, angular and tabular masses of these sand-stone rocks. All this leads to the decision, that the rock in question is the new red sand-stone, and the lower division of that formation as defined by MACCULLOCK, otherwise the principal compact rock is by no means so tender as to be unfit for economical purposes. On the contrary, it is a hard, glassy, splintery substance, evidently composed of fine grains of sand held together by a solution of silica, and assuredly not a free working stone, though it is squarred with some difficulty, and failure, into appropriate masses, and every where used as the common building material. Varieties of less frequent occurrence, and differing little from the principal rock, except in being somewhat softer, are hewn for the architectural purposes of the small temples of worship, and chisselled to produce alto relievo representations of the various Deities, &c.

The trap mantles round at the feet of all these sand-stone hills, and renders them isolated as far as regards the surface of the land. The angular masses composing the hills, differ much in measurement, whilst they are set together very closely in a horizontal position; or if any remarkable interval exists between the masses, where the vertical separation occurs, it is generally empty, no clay, no debris, nothing will be found. The massive bi-coloured blocks are not confined to any particular spots, they are casual every where; and the same is to be said of the slaty species, for a nest of this latter will now and then be seen with an immense mass of the common characteristic massive kind resting upon it; though at *Maswási*, *Satgerh*, *Garspur*, *Bilsa*, and *Narsinhgher*, there would appear to be a continued stratum, occupying a place in the whole line of the hill, at each of these places. Often at the ends of the hills, there is a bluff ragged perpendicular escarpment, and of course the rock is exposed from the base to the summit. Oftener there is a very easy slope, both at the ends and along the sides from the edge of the trap, that is the base of the hill, to within twenty or thirty feet of the top;—from this the rock continues upwards precipitous and rugged, and the crest is gained only after difficulty and search for particular points. The matter that gives the slopes described, is merely and exclusively the debris of the parent rock; and the vegetation, which clothes the surface, springs up between the fragments, time and the elements having worn off matter from those fragments, and so generated something of a soil beneath them

I might have mentioned before that the principal quartzose sandstone, that which I have described, when first fractured, and brought from the quarry, is of a beautiful sky blue, which soon by exposure turns to such as the specimens shew it, a salmon color or flesh color, or slight modifications of these. The slates of *Satgerh*, if they split off less than two inches and a half thick, are too friable and are thrown aside as waste. Some of the quarries are already abandoned, and the whole appear to have been commenced about half way up the hill, on the crest of the more sloping part, at the eastern end, and thence along both sides to some distance. A slow fire of stout sticks of green-wood, is placed on the inner side of the table worked, which at length cracks it down about a foot, and as a whole, it is then tapped into parts of the required length and breadth for paving, eves of houses, &c. It is the slates of *Maswási* that answer for roofing, these are generally something better than half an inch thick, and they are flexible, that is to say, the effects of the sun warp them, so much so, that if put on with a cement, they crack and break. Finally I may add, that a thin covering of refuse and stoney stuff, crowns the summit, resting upon table-shaped pieces, which repose on larger cubic masses, and thus far downwards the aspect of the whole is bare, rugged, and either perpendicular, or overhanging at the sides and ends of the hill. To the cubic masses succeed a stratum of slate, after which again the massive in large blocks; both these covered by the debris, which I have spoken of, as forming an easy slope to the sides and ends of the hills, easy as to the length, but of troublesome ascent, because of the looseness of the component material. Such is the hill of *Satgerh*, surrounded on all sides by the trap, and such too is the predicament of every sand-stone hill, throughout this trap formation, with exception to a continuous stratum of slate, which of course is comparatively of infrequent occurrence, though small nests, or patches of it will always be found in almost every sand-stone hill exhibited through the trap.

A conglomerate or breccia, having an argillo calcareous paste, coloured red by the oxide of iron, and enveloping angular pieces of various sizes of the proximate rock, will often be found at the feet of these isolated sand-stone hills if a streamlet winds its course near; or there will be at such points, pudding-stones, and breccias, varying in color and aspect from this described, and occasionally too in having an argillo siliceous instead of a calcareous paste; but neither these nor that just described, are of any geological importance whatever, and the same may be said of the trap tuff.

Whether a well be sunk in the trap, or the sand-stone, the water is always found at a very easy distance. It may often be come upon, even during the dry season, within three feet of the surface in the vallies; sometimes it will be so low as twenty-five feet, whilst the medium is about twelve, and from that to fifteen. It is the toad-stone that limits the depth if the well be excavated in the trap;—the sand-stone is of itself sufficiently consolated and retentive if the shaft has been sunk in it. If the edge of a hill or swell is pierced, of course the vertical height of such swell or hill must be added to the measurement just given, for instance the well on the edge of the hill at the mint of *Ságar*.

The surface of the slope, where this well was opened, was thickly strewed with large black wacken boulders, and these continued for some little depth below the surface, enveloped in a dark reddish rusty ferruginous wacke clay, succeeded by a bed, ten or twelve feet thick, of large angular pieces of a deep chocolate coloured basaltic hornstone, underlied by a bed of yellow clay, which yellow clay or lithomarge formed indeed, a sort of coating or lacing to the superincumbent hornstone. To these followed a stratum of limestone, similar to that of the cantonment wells of *Ságar* resting upon the softer amygdaloids, which I have numbered: In these amygdaloids the water presented itself at a distance of forty-seven feet from the surface.

The following are the strata met with in a well in the cantonment of *Ságar* on a swell of trap.

	F.	In.
Rubbish and soil,	1	6
Indurated wacken in angular pieces of uniform arrangement,	10	6
Wacke changed by calcination into a species of puzzalana,	1	0
A thin black streak (rather remarkable) a vegetable deposit, changed by calcination, so as to disintegrate and fall to pieces in water,	0	3½
A white, hard, earthy limestone, sometimes effervescing weakly with acids, sometimes not at all; small yellow specks of calcareous spar are seen in it, and occasionally a concretion of a purplish grey colour occurs, violently affected by dilute muriatic acid,	23	0

Wacken

	F.	In.
Wacken with fibrous carbonate of lime and ditto in veins with calcedony, ...	7	0
An amygdaloidal wacken similar to the toadstone of England,	6	0
Total to the water,	49	3½

The difference in depth that occurs in the vallies, before the water is attained, arises from the form of the vallies being always concave, and the basaltic black mould deepest in the central parts. The soil whatever is its occurring thickness, must be pierced, and also the indurated wacken or basalt, which ever it may be, and then the water is found resting on wacke' clay or amygdaloid.—The sand-stone keeps up the water even to a higher level than the amygdaloids of the vallies;—and the occurrence of either of these rocks forms all the phenomena of water in these districts.

Proceeding from the centre of the cantonments of *Ságar*, and traveling westward, you descend and cross the flat, which is the general parading ground, and at its confines, you come to a small isolated rise of sand-stone on your right, on which is built a *búsah* godown and a bungalow, and on the left a ridge, a branch from the sand-stone forming the basin of the *Ságar* lake; passing the town, and a little beyond the wall on the western side, a rivulet is crossed; then the road leads by a gentle ascent for two miles, to a low swell of trap, through a gorge or opening in which you enter the valley of *Bapyle*, and find a trap range close on your left, and one of sand-stone on your right, five or six hundred yards removed, forming the southern and northern sides of the valley. This valley is the practice ground of the Artillery, and must be at least three miles in length. At the western extremity another range of sand-stone occurs, either end of which range is within view, though it is elongated N. and S. to some little extent. A high rugged romantic hummock, capped, in a picturesque manner, with a disproportioned mass resembling a rocking-stone, is joined by a low neck to the main sand-stone range here, and partly on the declivity of the main sand-stone, and partly on the low neck is situated the village of *Bapyle;* opposite the hummock, only separated by a little broader space than is occupied by the intervening road, thetrap range, the southern boundary of the valley, comes to a point, where is seen the lime-stone, and the flesh coloured cherty matter, forming a belt round the base of the hill, and lying about in large whitish and greyish masses. The trap range does not expire at this point, it merely, instead of continuing as it had done heretofore in an east and west direction, turns suddenly to the south, and sweeping round to the west again, forms by so doing another large valley, along the northern side of which you proceed on the route after leaving *Bapyle.* The river *Dasáon* is crossed at *Sehorah,* thirteen miles from *Ságar,* and then *Gúmhariąh,* another village occurs, the whole way being on the trap, and the road at a little distance from the trap and sand-stone hills, until at length you gradually ascend the sand-stone hill of *Ratgher,* twenty six miles from *Ságar.*—This hill is wedge-shaped, lengthened out east and west, and at the west end the fort is placed on the brink of a high perpendicular cliff, at the base of which cliff flows the *Bína* towards the north. To cross the *Bína* you descend the ridge of sand-stone before you reach the fort, turn out of the village down to the right, or northwards into the low ground. The ford of the stream is filled with large masses of sand-stone, and is to the traveller, particularly at night, very troublesome to pass.—After gaining the west bank fourteen miles over an undulating tract, having a gentle ascent, brings you to *Bagrode,* where commences a trap range on the crest of which you proceed to within three miles of *Garspur.* During this course, you see to your right a very extensive plain, studded over with trap, and sand-stone hills of various forms and aspects, and among these the remarkable sand-stone hill of *Teonda*, with its summit presenting the appearance of a hill fort wall, with its buildings within. The route by *Teonda* from *Ratgher* to *Bilsa* is often taken for wheel carriages, to avoid the pass of *Garspur*. This pass, the summit of which is about three miles from *Garspur*, occurs in consequence of the road descending the southern side of the chain, the crest of which it had hitherto occupied in an east and west direction. The chain too here becomes forked, one limb stretching south west in a straight line, though not with perfect continuity of existence, to near *Raisen*, the other proceeding directly west to the *Betwa*. In the angle thus formed the road descends diagonally, and is extremely rough. It is covered, from the highest part to the lowest, with large globular and angular masses of compact and amygdaloidal indurated wacken, of a black colour, whilst the enveloping clays, in some parts of the line of descent, appear yellow, in others a dirty reddish brown; and there likewise occur at least two strata of the characteristic hard white lime-stone, the one rather above the centre, the other near the bottom. At the bottom or base of the hill there are collected innumerable masses of the same black boulders as belong to the hill, intermixed with pieces of black horn-stone shewing veins of white quartz; also knobs of indurated clay, or semi-formed jasper of a yellow color, or yellow and green two colors; botryoidal and mammillated lumps of a yellow horn-like chalcedony decaying, and variegated by the green earth contained; geodes of a pseudo amethystine quartz, often filled completely with confused crystallizations of the same, intermixed with balls of either a yellow, or pure and transparent calcspar; thin tables of quartz; small flattened pieces of common chalcedony;—thin tables of quartz, white and opaque alternating in layers with chalcedony, greenish grey and translucent, and coated externally, on the flattened sides with crystals of quartz small and brilliant, and other similar siliceous and calcareous matter, (the latter not separate and alone,) such as once probably was more intimately connected with the amygdaloids, and which now for ages have in the main resisted the force of time and exposure. The moment you are clear of this fallen matter at the foot of the pass, you step on the sand-stone, which is exposed to-day in the whole axillary part, the bounding trap ranges resting upon it. It is uneven, much covered with fragments; swells and hillocks appear upon it, and amongst these that on which is placed the village of *Garspur*, higher than the rest somewhat, but not so high as the contigu- us trap. It is situated about a mile and a half from the foot of the pass, and it possesses some little length, or at its foot the road runs about half a hile, in a W. S. W. direction. After leaving the red ground, and coming in the black soil again, the sand-stone still continues to attract occasional ttention, protuding up through the trap, until you have passed the dis- ance of four miles. From this point, for twenty miles, there is a general in- lination of the trap land to the *Betwa*, the hills being farther, and farther emoved from the view, as you advance in the large open cultivated plain, t the W. S. W. extremity of which stands *Bhilsa* on the east bank of the *etwa*. Here the sand-stone occurs as a large plat of some hundred yards ameter, generally even with the trap; but in the central part, it sudden- rises up, and forms a curious clump about one hundred and twenty feet igh and flat at the top, where there is just sufficient area for a Mos- m tomb, and another small building or two, remarkable in the distance om their white appearance. If *Bhilsa* be taken as a point, and a radius of six miles swept about the west bank of the *Betwa*, it would every where ass over sand-stone hills; they are much clustered thereabouts. *Khana- drah* where is seen a very anciently sculptured rock is situated amongst lem. The town of *Bhilsa* is placed on the east bank of the *Betwa*, etween it and the solitary sand-stone rise alluded to. In a N. W. direc- on a bed of iron clay slopes off this rise, so that the *Betwa* and the *theis*, which joins the *Betwa* a little northward, cuts through it, and the angle, formed by the junction of the rivers, is occupied by it; but, after having gained the west bank of the *Bheis*, it is soon lost, The road now continues on the trap, the hills for six miles being solely of sand-stone; more west than this it is merely a trap plain on which occurs *Kamkera*, twelve miles from *Bhilsa*. Beyond *Kamkera*, the route being now to the northward of west, the plain still continues for five miles, and then you ascend and cross a range of globular trap hills, distant from *Barsia* ten miles, with nothing remarkable in the interval. *Barsia* is on a large mound of amygdaloidal iron clay, sterile and bare in some parts, apparently highly productive in others; in the immediate vicinity of the town it is gravelly and red in aspect. Four miles in advance, or at *Ránagerhi*, this clay again presents itself, rises even to the rank of an ore, and is as such worked, and the produce sold sufficient for the purposes of the bazar of *Barsia*. Immediately around *Danaora* the sand-stone hills shoot up. *Kalukera*, sixteen miles from *Barsia*, is on the trap; the *Sumera*, a small stream, winds about the village, washing out its way through large blocks of wacken and basalt. The fort is built of egg-shaped masses of the latter, truncated at one end, which end is set outwards, something like the flint with chalk to be seen in some of the ancient houses of Hampshire, such as Chawton-house and Farleigh Wallop, though the stones here used are four times as large as a common flint. Between *Kalukera* and *Narsinhgerh* (a march of fourteen miles) you pass the *Parwa* and *Párbati*, only worthy of notice as shewing in their beds the trap and basalt covered with a whitish coating, and cracked in to various prismatic shapes. The sand-stone range at *Narsinhgerh* runs directly N. and S. beyond the reach of sight. The village is situated in the deepe rt of a circular hollow formed by the partial winding of the hills, and the trap has there found its way, though a basement of sand-stone completely occupies the narrow throat or entrance over which the road leads into the hollow. The trap is composed of balls decomposing of the concentric lamellar kind, and the water in a well, where this trap was identified, was fifteen feet from the surface in the month of June. Rising out of this hollow you go up a very long and steep ascent of sand-stone, and when the crest of the hill is gained, there is but a trifling comparative descent on the west side to reach the trap. The space between this and *Bhopalpur* has nothing of interest, the country is more undulating, and more open, hills and hillocks are less seen. The *Kassa* and *Dúda* rivers, occurring before you reach *Bheinsa*, differ nothing from the *Parwa* and *Párbatí*, neither does the *Newas* in advance at *Bhopalpur*. It is fifteen miles from *Narsinhgerh* to *Bheinsa*, and ten more brings you to *Bhopalpur* on the banks of the *Newas*, and to an extensive bed of basalt (the Rowley Rag,) not rising above the surface; thirty-six miles beyond this point in the direction of *Patan* and *Kota*, i. e. at *Bhalta* the trap formation ceases. It is seventy-two miles from *Ságar* to *Bhilsa*, and eighty-two from *Bhilsa* to *Bhopalpur*. In the first part the vallies and low lands are generally pretty well cleared and cultivated;—in the latter they are wild and their fertility neglected, they are overgrown with brush-wood and jungle, and cultivation, at least along the line of march, is only seen in small patches about the villages, just sufficient for the support of the inhabitants.

Departing from *Bhilsa* and taking the route to *Hasanábád*, the sand-stone hill of *Raisen* is met with at the distance of fifteen miles. It is in shape like that of *Rátgerh*, but the highest point is the east end, and the fort is perched upon it facing that quarter. It is very conspicuous for many miles around, and said to have been built by the celebrated King of *Ayodhyá*, as a place of refuge from the temporary anger of his brother, and that the hill arose at his desire, but whether with the aid of an igneous or aqueous power the upheaving was accomplished is of course the question here requisite. *Banchor* the next stage, as its name imports, is the entrance to a dense forest of timber trees, crowning the summits, and sides of a very long winding sand-stone range, upon which the road passes through *Chiklod*, *Kuliagerki*, and *Akalpur*, or a distance of twenty-four miles, and in a westerly direction, and then turns south or down the slope of the hills twenty miles, through *Nezer Ganj* and *Chouka* to the alluvium of the *Nermada*. The road descending is extremely rugged, and occasionally slippery from the size and position of the slabs, it is in fact nothing more than a water course: It is sixty-eight miles from *Bhilsa* to *Hasanábád*. The edge of the alluvium is three miles from the *Nermada*. The sand-stone peeps to day at *Hasanábád*, and is seen no more. Fifteen miles over the black basaltic mould or alluvium brings you to *Petraota*, where commence primordial rocks, ending in the granite of *Nímpáni*, *Shahpur*, and *Beitúl*.*

I ought to have stated, that the trap range branching off at *Garspur*, approaches very near to *Raisén*, and at *Banchor* forms the eastern boundary of the small valley there; and then after bending about, in a southerly direction, and skirting the sandstone, it proceeds eastwards by the source of the *Desaon*, *Sírmao*, *&c.*, forms, in fact, the southern boundary of the trap formation as described.

Northwest of *Ságar*, or in the direction of *Seronj*, and north, or in the direction of *Maltoun*, still the country is precisely the same, except in the latter case, the sand-stone hills predominate. Eastward of *Ságar* the trap is at *Sanowda*,—so is it at *Shahpur*, or a march beyond, and ceases only near the nameless rivulet between that place and *Pathariah*.

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* Between *Kaisler* and the *Bhora Nadí* there is coal. The *Towa Nadí* should be followed to its source, or until it is shewn from whence it receives the coal fragments found in its bed.

North-east of *Ságar* the sand-stone often appears, but only as swells rising little above the general level. The trap prevails until you have passed *Sanwa*, three miles and a half, there it ceases entirely, distant from *Ságar* forty-five miles. From *Sanwa* east to *Sátpára* and *Pancham-nagar* in the lias, it is not more than nine or ten miles, and these places are about the same distance from *Hírapur*, due north of them. A section made from *Hírapur* to either of these places, and from them to *Sanwa*, would be highly interesting, and most probably establish clearly the relations of the granite, conglomerate, new red with its overlaying trap, and the lower lias.

Where the trap ceases, it does so abruptly. It possesses a vertical thickness of about sixty feet, and it has been cut down to make the slope easy for the road. At the foot of this short pass, which is still very steep, is the sand-stone supporting the trap; and this sand-stone is not now a hard, glassy, difficultly frangible, splintery substance ; it is become a fine grained, white, saccharine mineral, with a flat even fracture, coloured externally a light red ; and with the exception of one fall, about half a mile after leaving the trap land, it presents a very even surface, its blocks being freed of debris forming a pavement base for the road, a distance of four miles; the sides of the road meanwhile, shewing much overlying loose matter with long grass intermixed, and occasionally trees, as you advance, approaching more and more to something of a timber size. Only one small hamlet presents itself distant from the road side on the right hand, perhaps a mile. At the expiration of this wild flat, three hills are crossed in succession, composed of the sand-stone masses, rather sparingly and loosely set together in much red clay, and quartzose matter, and covered very densely with jungle and forest wood. These hills are of no great height, but being separated one from the other by ravines or water-courses, they are short, steep, and troublesome at the points of separation. From the verge of the summit of the last hill, which summit is more than a mile in breadth, you look down, over an intervening conglomerate range, into the valley of *Hírapur*;—and on descending from the summit, within one hundred yards from the base, speaking as to the line of road or slope, not to the vertical height, you see the new red sand-stone reposing, in a horizontal position, on a stratum of brownish black ferruginous clay, and earthy iron ore of the same colour.—Was not the sand-stone to be seen actually reposing on the stratum just mentioned, still that a change had taken place no one could fail to observe; for the ground, from being bright brick red, suddenly changes to a brownish black, with a harsh gritty gravelly tread. as if you were in the neighbourhood of some great foundery; and so it continues to the base of the hill, and onwards along the low ground as far as the conglomerate hills. These conglomerate hills surround the whole valley of *Hírapur*, and are heaped up immediately on the granite from whence they are derived, or else they rest on horn-stone petrosilex. The individual hill at the south-west point, or the point at which the road enters the valley, is not more than two hundred yards removed from the base of the sand-stone hill,—only separated by a small hollow or curviture, strewed over with lumps of iron ore and pieces of quartz and felspar, &c., but not a fragment of the new red. The component matter of this conglomerate hill, as well as all the rest around the valley, is a sombre, dark red coloured clay. enveloping variously formed large masses, the conglomerate, or Breccia proper, made up of angular pieces of white felspar, and occasionally grey pseudo limpid quartz, seldom less than an inch in size, agglutinated by a highly indurated cement of the same sombre ferruginous clay just noticed; or the paste is still harder, common quartz discoloured by the oxide of iron. From the conglomerate boundaries to the centre of the valley. the granite every where is open to-day and laid bare; it rises also in the centre, sinking towards the bounding hills, and iron ore is strewed about all over those hills, and at their feet, even on the granite. The form of the *Hírapur* valley is oval; its longest diameter is from west to east, and it is in that direction about a mile; from south to north it is not more than a quarter of that distance. About the centre, or perhaps a little to the westward of it, is a large pond, on the north bank of which is the village, and near it, or on the east side, a small square *Gerhí* or *Fortlet*. On two mounds of granite near the *Gerhí*, also on a swell of the same on the south edge of the pond, no where else, masses of gneiss, some half dozen in number, are sticking up, which, from their slab form and slight inclination, oddly and much resemble old tomb-stones in a church-yard. Both the gneiss and the granite if they have any inclination dip to the S. W., but of the conglomerate, it being a heap of clay and large stones, nothing very satisfactory can be said; here and there, amongst the rounded and angular masses, one or two larger than the rest, would seem to stand up, conforming in position to the gneiss, with their broader sides something sloping to the same quarter as the granite, and the gneiss, viz. to the S. W This sketch brings the trap and sand-stone to their N. Eastern limits.

At *Hírapur* is seen the granite, capped by heaps of ferruginous conglomerate, which conglomerate is connected with a stratum of iron ore, on which the new red sand-stone is seen to repose:—All this within the space of a few hundred yards. The new red sand-stone, from this point, continues, in the direction of *Ságar* bare, and exposed, freed from any overlying rock, a distance of six miles, or to where it is met by the trap, when for forty-five miles the two together progressively increase in height, until at *Ságar* they have attained their greatest elevation, or are at least one thousand feet higher than the spot, where the just noticed connection commenced. If a line be prolonged from *Hírapur* through *Bhilsa* to *Hasanábád*, or that quarter of the compass towards which the primordial rocks at *Hírapur* would seem to dip, such line will have in it almost all the principal points, where the sand-stone protrusions are entitled to the rank of hills, and where they are more elongated individually, and more clustered together; for instance, *Dhamúní*, and *Maltoun*, *Gherpára*, and *Sátgerh*,—*Bapyle*, *Rátgerh*,—*Gráspur* and *Bhilsa*.—The eastern edge of the sketch, as stated in the commencement of this notice, is where the thin covering of the lower lias lies on the upper portion of the new red rock series, viz. clays, marls and calcareo arenaceous sand-stones, tender and often variegated, and it is desirable to note in particular that such is the case. At the descent to *Tendukaira*, or at the S. E. corner of the trap, it is a sand-stone rock; but the connection of this rock, with the subjacent matter along the south boundary, is concealed by the basaltic alluvium of the *Nermadá* interposing. The western limits join the trap of *Malwa*, and therefore it need only be added, that I bring the sand-stone as far west as *Narsinhgerh*. Along the north side probably there is sand-stone the whole length, it certainly does reach up to *Maltoun*, and forms the bounding rock thence to *Hírapur*; and iron ore occurs at many points in that line similar to what it is at that particular spot.

To conclude:—The rock about *Sehore* and *Bhopal* is, upon good authority, considered as similar to that of *Ságar*; although there was information given, that rock salt was there produced, and of course the mind conceives *Gypsum*, &c. as equally existing, or in a word, that the superior portion of the red marl formation was to be found west of the somewhat diagonal line pointed out; but the accuracy of this last report is at present to be doubted, more particularly, as *Gypsum* is only known in the *Ságar* bazar as a production of *Rájputána*, and the salt chiefly used is that of the *Sambher* lake, annually brought along these latitudes, and sold by the *Binjaris* as far east as *Sergúja*. However be this fact, it is, with the exception now noticed, that I wish to offer the sand-stone of the districts described, from a general personal acquaintance with the whole, as remarkable for the great extent of range it possesses, for the unique abstracted nature of the thing itself, and mode of occurrence :—It is ever the same thing at every point of view, void of clays and marls, or any other interstratification, it is the same identical mineral, protruding itself through the trap, (where the trap overlies,) in large angular masses set together horizontally without cement ;—a substance of apparent simplicity of composition, fine grained, hard, vitrified and brittle where it is localized in the midst of the trap of supposed igneous origin, and a free stone of flat even fracture beyond those localities. Highly micaceous and variegated sand-stone slates occur in it in nests, or as continuous strata. The massive rock is itself also often bi-coloured, rarely many coloured. It might be explained and named as the middle division of its formation, but it is not seen to rest on a conglomerate of its own, on the contrary, it is itself seen, at *Hírapur*, to rest immediately on a conglomerate incident to the granite rock there occurring.

The lime-stone of the trap is a hard white earthy substance, enveloping a few small particles of a yellow calcareous spar. It occurs constantly as a component part of the hills and swells,—not of the lower grounds, unless as detritus, in small particles washed down from the hills, when it intermingles with the black mould, and then that soil becomes, from the intermixture, remarkable for its fertility. It deserves attention particularly for the semi-calcination, and sometimes more, which it would seem to have undergone, and generally for its defiance of classification, and for the jumble, and apparent dislodgement from original position, which it now exhibits heaped up in the trap :—And, if with these considerations, it be reflected that there is no oolite, no chalk, nothing in a word posterior to lias, the hope may be indulged, that the chert and calcareous dendritic fragments, occasionally found will, together with other to be substantiated facts. eventually establish it as a continuous portion of the neighbouring lias, disguised, and displaced when the trap was erupted, or by that explosive power and plutonic heat, which glazed and hardened the sandstone rock.*

As to the trap it is here a very extensive deposit, though still but part of a whole. All its rocks are basalt, or matter of near alliance with it, and composed principally of hornblende and felspar in an earthy state. It is altogether an earthy deposit ; varieties of green-stone, or basalt, or any rocks of a distinct crystalline texture are wholly wanting, and by such deficiency so many others of the trappean list are equally, it would seem, not to be found ; and the idea obtrudes, whether the circumstance of a simple mineral, like this sand-stone described, being the including rock, or basin, has not debarred complexity, and preserved to the trap singleness of feature and texture, and manner of being. The color of the harder basalt is either greyish black, or jet, and that of the softest kindred clay mottled greenish grey ; and all other varieties, as to induration or complexition, vary between these extremes. In the hills, the indurated masses have mostly their angles rounded, and appear heaped up together with a variable proportion of wacke clay, added to which, there will be seen frequently, a patch or lime-stone stratum, occurring nearest the base. The base of the hills is invariably broader than the summit, and, if the sides of a hill are smooth and even, balled trap or basalt, often a concentric lamellar variety, will be the principal component matter, decomposing and decomposed into a predominating workable clay, still shewing the parallel converging layers. The smaller vallies appear much scooped, or concave, and underneath their black-looking soil lies wacken or basalt, in form and size, about a cubic foot, disfigured, and often arranged in an uniform manner. The globular wacken and basalt partially supersede this arrangement in the low grounds, but neither basalt, nor wacken, with step-like uniformity, will ever be found forming a hill. Some one or other of the amygdaloids, particularly the toad-stone, succeed the soil, and compact trap rock in the vallies, and they are often observed occurring at the feet of the hills; but these latter, it should be remarked, are often merely this globular trap, distinctly thrown up on a sand-stone basement, or flat. *Narsinhgerh* remarkably shews the trap every where surrounded by sand-stone, and the lake of *Ságar*, on a larger scale, is a distinct basin of sand-stone with an inner coating of trap. Altogether it may familiarly be depicted as a dark superficies speckled with spots of red; the bird's-eye view also presents the thing as a net work scene, the interstices being formed by the numerous hills, and low chains of hills, winding about. No sudden brush of the ocean could have left such remains as are here seen, and, unless the occurrence of stilbite* be decisive, there are no facts to plead for the aqueous origin of the trap, except the all-pervading character of its occurrence, and its possessing an axis or general line of bearing; but neither of these, indeed, plead exclusively for it; whilst, on the other hand, common observation here forcibly incline the mind to recognize an opposite theory, and imagine the action of a globe of compression, or rather of a common mine:—The effort is made, and the entonnoir formed by the more verticle rays sending upwards the stuff, and strewing it in heaps all about; whilst those rays, that are more inclined, will either compress, and shake, or split, and penetrate according to the various natures of the materials of which the sides are composed ; applied to the trap, it will thus be an overlying rock, whether it be, as it is seen here, only on the surface, or whether it occurs, as it so often does elsewhere, and here too perhaps below the surface, interstratified, entangled, and in what not position in other rocks. The works of after ages, by means of either agent,—the ocean, for instance, acting through those ages, might have exercised denudation, and disturbance, until only a portion of a more horizontal ray is occasionally to be seen, indicating an explosion somewhere, either proximate, or remote from the spot:—a stratum,—a dyke or a vein occurs of no obvious connection. If the simile of a mine be at all admissible, it may be carried on and said, that compared with the solid contents of the globe, the product here seems to have been from a line of *Fougasses* continually working results through a long course of time; the ruin lies about, a small portion of which is a half calcined lime-stone, can it once have been the *lias?* and the chert of *Bapyle*, and the small fragments occasionally found of a yellow dendritic lime-stone, the only aids at present in corroborating the idea? and the clays, the yellow and the deep chocolate, and the marly ochres, are they the more unchanged matter, and the laterite an iron ore disfigured and impoverished? The cellular, or honey-comb lava-like variety of trap occasionally is met amidst the abundance of other kinds; whilst the sand-stone rock is, as a remains, shook and split and vitrified, but not displaced or inclined:—The fluid matter seems to have shrunk and sunk, and thus, in a great measure, arises the phenomena of the trap in the low grounds, and the disrobed naked appearance of the sand-stone islets, as if their clothing had slipt down. But the incumbent waters by their under currents, not by violent agitation, would seem to have rounded the masses, and further confused the heaps thrown up, and, after the igneous agency had ceased to act, every trace of the sphere of action would be by those waters quickly obliterated. The small hummocks, which occur so often, and more particularly at the ends of the hills joined by a low neck to them, are mostly amorphous, and then composed of the harder materials;—but often they are something of a cone or a truncated cone, and their component matter soft. They are here of no importance, having been for ages exposed to day they have become worn at length into that shape which best resists much further demolition, and so now remain.

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* The first noticing of the peculiarities of the lime-stone is due to Captain FRANKLIN, and the idea of the oolites and chalk is given nearly in his own words—but I am responsible for hazarding publicity.

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* It has been said that the occurrence of stilbite is decisive of the aqueous origin which is the reason why I mention stilbite being found.

It is almost superfluous to add that no fossile remains have been found by me.

The following is a summary of the foregoing sketch: The latitude of *Hírapur* is occupied by a primitive range, and so is the skirt of the alluvium south of the *Nermada;* in the longitude of *Udayapur* will be a western limit, and a granite range, crossing the *Nermada* at *Jebelpur,* and stretching northerly, forms the eastern boundary. This basin elongated E. and W. formed of primitive rocks, has, in its interval or hollow, the sandstone deposit, in some one or other of its forms, exhibited nearly throughout;--obscurely as when seen through the trap, or thinly covered with a coating of lias; or openly as in the hundred and ten mile line from *Ságar* to *Jebelpur*. From *Udayapur*, or the western limits to the central part, *Ságar*, the trap rocks blacken the surface, and at *Ságar* they rest on the sandstone, which appears not to have much intermediate between it, and the proximate primitive rocks. It is a continuation, and a sort of north eastern bend of the rock of the *Malabar Coast* from *Baroda* as a point, and itself contains more, perhaps, than fifty-four thousand square miles.

IV.

REMARKS

ON THE

GEOLOGY OF THE COUNTRY

On the Route from Baroda to Udayapur, via Birpur and Salumbher.

By JAMES HARDIE, Esq.

Assistant Surgeon, M. A. S.

In this communication I do not pretend to give a correct geological description of the country through which I have passed. This would be an undertaking of great difficulty and one which would require that our observations should be made on a much more extended scale, and with a far greater degree of minuteness than can possibly be done by a traveller, who is merely marching in a rapid manner from one point to another. Such remarks, however, as the following, if they be correct, may prove useful in as much as they afford an opportunity of comparing notes with the observations of other travellers, and thus we may eventually succeed in obtaining a pretty correct knowledge of the minuter Geology of India, the general features of which have been already described by one of your members.

From *Baroda* to *Bírpur*, a town of considerable extent, situated about twelve miles N. W. of *Lúnawara*, and distant from *Baroda* about seventy-six miles, the country affords little to interest the geological observer. Proceeding by the direct route via *Balasinur*, and till we reach the last mentioned town, a distance of nearly fifty-six miles, in a northerly direction, we perceive nothing but a uniform expanse of alluvial soil. We now, for the first time, observe rock formations and several gentle rising grounds give to the face of the country in the neighbourhood, a waved outline. *Balasinur* is situated on one of these rising grounds, and the only rock which presents itself is a conglomerate, principally composed of agates and other quartzose minerals. Some of the agates were of considerable size. This rock is not stratified, and appears at the surface in the form of large lenticular masses. It is perhaps a similar formation to the cornelian rocks in the neighbourhood of *Barra*, but, as I have seen no good description of these, I can only state this as a mere conjecture.

Distant from *Balasinur* ten miles, still in a northerly direction, stands the small village of *Pandua*. In its neighbourhood are seen several small rounded hills or rising grounds presenting the bare rock at the surface. On examination I found that these were composed of different modifications of granite. The first was a very close grained grey granite composed of greyish felspar, translucent quartz, and dark colored mica with hornblende, occasionally disseminated through it. This passed into a coarser granite composed of large masses of reddish grey felspar, nearly transparent quartz, and silver colored mica. Both the mica and quartz occasionally appear crystallized, I could not procure a hand specimen in which this was distinctly shown. The one in my possession, and which shall be forwarded to the Society, is sufficiently characteristic in as far as regards the mica. Some of the masses of quartz in this granite were upwards of a foot square, and many of them nearly transparent, through the substance of which prismatic crystals of schorl were seen to shoot. These rocks were not stratified.

Birpur is situated ten miles N. of *Pandua*. The route for the first five miles lies over the usual plain of *Guzerat:* we then enter a more hilly country; the hills, however, are very low and their summits are occupied by a table-land. *Birpur* stands on an elevated situation, and the low hills with which it is surrounded, are covered to a great depth, as may be seen by the ravines and nullah courses, by an alluvial soil similar to that of the plains. Owing to this circumstance I had no opportunity of examining the rocks in situ—the stone used in building, and from the quantity of it seen it must have occurred in great abundance in the neighbourhood, was a very compact quartzose sandstone, or rather a ferruginous quartz of a red color. From the appearance of the fragments it must occur distinctly stratified.

We had now left the rich and highly cultivated plains of *Guzerat*, and had crossed the barrier of a hilly and jungly portion of this district, not only the face of the country had changed, but the appearance and character of its inhabitants. Heretofore we had a rich alluvial soil, cultivated by a comparatively speaking civilized, or at least a more peaceable people—numerous thickly inhabited towns and villages were seen scattered over it—it is watered by numerous tanks, and wells, and rivers, and the country resembles more the richer portions of Bengal than any other part of India which I have seen. The surface of the country passed does certainly not present much to attract the notice of the Geologist; with the assistance of boring instruments, however, much valuable information would, no doubt, be obtained, and an interesting comparison might be drawn between the alluvial formation of this district—that of Bengal—the

London clay formation, and other similar formations both in Europe and Asia.

Whatever might have been the agency, or the succession of agencies, concerned in forming the alluvium of *Guzerat*, it is abundantly obvious that it could not have been gradually formed by the debris of the rocks in the mountainous portions of the district washed down by rivers, nullahs, &c. From this source a portion of it might, no doubt, be derived. By its extent, its depth, the high situation which this deposit frequently occupies, (as at *Bírpur*, just mentioned) we may learn that it must have been the result of some more energetic cause.

The extent of the conglomerate formation at *Balasinur*, I had no opportunity of ascertaining, nor do I know its relative position with regard to other rocks—it probably, however, rests on the granite which underlies the alluvium—might not these conglomerates be cotemporaneous with the lower beds of the alluvial deposit, modified by some local cause, affording a cementing medium to the loose particle, connecting them together and thus forming a nucleus round which others would collect? This is a mere conjecture.

The hills at *Pandua*, were no doubt, formed by the outgoings of the underlying granite—a granite which appeared to me to belong to a very ancient variety—an older variety indeed than any which we shall have occasion to mention in the sequel of this paper. The crystalline nature of its component parts—the transparency of its quartz—the whole appearance of the rock, and the situation which it occupied, led me to draw this conclusion.

From *Bírpur* our march lay through a hilly and jungly country to a small village called *Dewárí*, six miles distant, in a N. East direction from the last. The hills were ridge-shaped, and their summits presented in the distance a uniform and even line. Their slopes were covered with loose fragments of the wells composing them. The preponderating rock was quartz, distinctly stratified. On examining a hill in the neighbourhood of my camp, I found the following series of rocks arranged in strata, which were highly inclined and dipping towards the N. W.: 1st, a rock of the nature of quartz rock, of a greyish color, and inclining to slaty structure—it seemed to be quartz rock passing into clay state—it was very hard however, and was principally composed of quartz. 2nd, a ferruginous quartz, of a reddish color; and 3rd, a pure white quartz. The last had nothing of a slaty structure, and, indeed, could not be said to be distinctly stratified. These three formed frequent alternations, the pure white quartz appearing in the shape of a series of unstratified beds interposed between the other strata.

Ten miles distant from the last, in the same direction, stands the village of *Panwára*. For the first four or five miles the country was covered with a thick jungle, and the line of march was enclosed by ridge-shaped hills which presented a bold and craggy outline—the rocks forming them were arranged in a highly inclined position, and consisted of different modification of quartz rock and clay slate which alternated with, and passed into each other. After having passed a narrow Ghat, which though steep, is not difficult, we entered an elevated plain, level and covered with a thick and apparently rich soil, in many situations well cultivated and over which are scatterred numerous fine trees. From the top of the Ghat where the plain commences to *Panwára*, is a distant of about five miles.

In ascending from the plains of *Guzerat* to our present situation, we have come at once among rocks of the oldest class, and we have met with nothing like any of the newer varieties. We have passed the western boundary of the great primitive district which forms a large portion of Central India, and which traverses from N. to S. the whole of the peninsula, being connected, indeed, at one point or another, with all the great primitive formations which exist in *Hindustan*. The rocks which as yet we have seen might be termed, perhaps by some, " transition." In the present instance I can see no use for this distinction. From the rocks which surround us to the more decidedly primitive ones we can trace a regular gradation. They pass into—and in many instances alternate with—each other. In short every consideration points them all out as belonging to one grand series of rock formation as the result of one general cause.

In the deposition of a formation so extensive, a long period of time would doubtless be consumed, and though the precise period of their deposition might be different in different instances—one being formed when the forming cause, whatever that might be, commenced to operate, and another when it was about to cease,—this, though it might modify the internal structure and appearance of the different rocks composing this formation would not justify us in including them under different classes.*

In the district of *Kutch*, towards the N. W. I believe, from specimens which I have seen, that a series of rocks of a newer formation than lias, and from that upwards, may be observed. I drew this conclusion from the very numerous fossil organic remains which many of these specimens exhibited. These remains were shells belonging to varieties which have been ascertained to be characteristic of the newer classes of rocks in other countries. Nothing of this kind can be traced here, however, and from the paper of Captain J. STEWART, in the Bombay Literary Transactions, the same remark may be made regarding the boundary of this great formation on the route from *Baroda* to *Mhow*.

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* I am uncertain with regard to the nature of the rocks at *Birpur* As I did not see these in situ, I cannot say decidedly in what class they ought to be included—they, perhaps, belong to a newer and overlying variety.

On leaving *Dawári*, we proceeded on the usual direction over the level plain before mentioned, till we reached the *Bhílpál* (i. e. a community of small villages) of *Hartúna*, which is situated eight miles distant from the former. We still found the surface of the plain covered with a thick soil. In some situation, however, small hills or rising grounds were observed which exhibited at their surface the outgoings of the inferior strata. These were as before quartz rock and clay slate, the latter was now much more abundant than formerly. Strata were still highly inclined and dipping as usual.

At this place *(Hartúna)* there was a great scarcity of water, and the *Gosáin* of the temple of *Náthdwára*, had sent some workmen to dig a well. They had penetrated about thirty feet through the rock in a low situation, and I had thus an opportunity, the first which had as yet offered itself, of examining the strata in the plain. I here discovered a distinct and separate formation from any which I had seen during this march in a series of overlying rocks. The first rock which presented itself, was a distinct sandstone, with a clayey basis, and of a soft friable nature. It was a variegated sandstone, with spots of a reddish color dispersed over a whitish ground. Below this was another variety of sandstone of a more compact nature than the last, and of a whitish grey color—it was a calcareous sandstone, effervescing with acids—the proportion of lime in it was, however, very small. These two were arranged in strata which were very slightly inclined.

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There can be no doubt, but that these rocks belong to a newer class than any which we have yet seen—the extent of the formation I had no opportunity of ascertaining—it probably occupies, at least, all the lower portions of the elevated plain on which we were encamped, the rising grounds, as we have seen, being formed of the nearly vertical strata of the underlying rocks. Nothing like organic remains could be traced, though I examined with care the different masses which had been thrown out by the borers. Through the above rocks a vein of quartz was seen to pass—it gradually narrowed from below upwards till it terminated at the surface, where it was about a foot and a half in thickness, the lowest portion of it seen, being about two yards broad. The quartz was of a pure white color and crystallize texture. It was not stratified, but presented the appearance of a number of rounded masses closely cemented together—the *Huttonian* might say, that it derived this form from having been ejected from below, the *Wernerian*, perhaps, that it had been a previously existing rent in the strata which had been filled up from above by rounded masses of quartz derived from the neighbouring hills, and which are seen strewed over the whole surface of the plain. The latter is certainly the more probable theory, as the masses of quartz were cemented together by a calcareous cement of obviously a posterior formation to the quartz.

In which precise class of rocks, the above ought to be included, I have had no means of ascertaining; in their nature and structure, however, they resemble the rocks of the new red sandstone formation of *Jameson*, and I should feel induced to consider them as belonging to this class. No rocks of a similar nature have occurred to me during my march, nor do I think that, in the country passed after leaving this, any do exist, for in almost every situation the vertical strata appear at the surface, it is more than probable, however, that the rocks examined formed

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a portion of a considerable formation which occupied the elevated plain under consideration, and which might extend in a northerly and southerly direction for a considerable distance. In Captain DANGERFIELD's map, a "granular course limestone" formation is laid down, as running from north to south the whole extent of his map, and passing in the neighbourhood of the plain in question. I have not seen any thing of this formation, it is not improbable, however, that the rocks just described, may be associated with it.

From Captain DANGERFIELD's map, it will be seen, that the communication now sent differs in many respects. In some instances, too, I suspect that we have called the same rock by different names. His sandstones and sandstone slates which he describes as skirting the western boundary of the great formation, may be the same as the rock here described as ferruginous quartzose sandstone, and his hornstone may be the stratified quartz so often mentioned in this paper. In some situations in *Mewar*, which I have visited, he has described as hornstone the same rock which I here call quartz—the very remarkable ravine which he mentions, as occurring at the bund of the *Udayaságar*, I have often seen, and the rock which is found there, and which he calls hornstone, is exactly similar to a rock of this part of the district, which I have classed with the stratified quartzes. That it is not hornstone, commonly so called, I have no hesitation in stating, and I cannot help thinking, that the adoption of such a name might give an incorrect idea of the formation in question, and might lead us to confound it with other formations. Where the quartz rock passes into clay slate, it might, perhaps, be named flinty slate. I prefer, however, retaining the general name of quartz, mentioning when it shall happen to pass into any other of the rocks, as for instance, into gneiss or granite, or mica or clay slates, into all of which in different situations it may be seen to graduate. Indeed, it appears to me that the very large proportion of quartz, both as an ingredient in the compound rock and in an unmixed form, is a very striking feature in the geology of this portion of India, and one which ought not to be lost sight of. I shall take the first opportunity of forwarding to the Asiatic Society specimens of the rocks found in this district, which, I trust, will bear me out in the opinion which I have stated. In Captain STEWART's account of the strata between *Baroda* and *Mhow*, no mention is made of any overlying rocks on the west side of the great formation, neither does the succession of rocks laid down by Captain DANGERFIELD, appear to have been observed by him.

By the above remarks, I do not wish to detract from the well earned merit of Captain DANGERFIELD. We are indebted to him for much very valuable information, but to make a perfectly correct geological map of this part of the country would require years of minute investigation, and in a climate like this could scarcely be effected by one individual—too much praise cannot be given him for what he has done.

Proceeding in the usual direction, we reach the village of *Pit*, in the *Dungerpur* district, which stands eight miles distant from the last. Immediately on leaving camp, the country became exceedingly broken and uneven, and numerous small rounded hills were seen exhibiting at their surface the vertical strata—quartz rock was still observed, but clay slate was the preponderating mineral. In a well near camp, in a low situation, clay slate was also seen. The clay slate was, in some situations, of a quartzose nature, and in others it approached to chlorite slate.

Ten miles distant from *Pít* stands the *Bhíl Pál* of *Ghátah*—for the first three or four miles the country was exactly similar to that just described, the jungle then became thicker, the country more broken and rugged, and, though the hills with which it was studded were still low, the scene was rocky and wild in the extreme. The hackery road, which is tolerably good, passes through a narrow Ghat, I proceeded myself by a higher route, winding along the edge of the ravines with which the country was intersected, and passing over the tops of the hills. The rocks were every where observed at the surface, and the almost perpendicular sides of the ravines presented to the view excellent sections of the strata. We encamped on an elevated plain surrounded by ranges of low ridge-shaped hills. Since leaving *Bírpur*, we have been gradually ascending, and the ascent of the last six miles has been much greater than usual. The rocks observed were different modifications of quartz, varying in color from pure white to a very dark brown. The pure white variety has not yet been seen regularly stratified, beds of it, however, alternate with other rocks, and these beds are traversed in every direction by seams and cracks, and have the appearance of being made up of a congeries of detached masses, varying in size from two or three inches to a foot in diameter, and closely connected together. The colored varieties are distinctly stratified and are arranged in parallel layers, varying from an inch to a foot in thickness. Their color depends on an admixture of the rocks with which they are associated, sometimes in very small proportion, and at others the proportion is considerable, many of them, too, derive their color from iron—the dark brown variety is a ferruginous quartz, very rich in this metal. Iron appears to be an abundant production in the country we have been describing, and several pretty good specimens of the magnetic iron ore presented themselves. The above quartz rocks were seen alternating with clay slates—in some situations soft and friable, in others quartzose—and chlorite slate. The chlorite slate was first seen three or four miles distant from *Pít*. About half way between the last mentioned place and *Ghátah*, we passed a small hill composed of serpentine. It was not stratified. The bed in which it occurred appeared, as far as

I could judge, of considerable extent, and in this part of the country I know it to be an abundant production. It was of a greenish colour, with a tinge of brown and grains of a metalic mineral, with a metalic lustre were disseminated through it. This was magnetic iron ore.

The clay slates passing into chlorite slates were the preponderating rocks, and in the neighbourhood of our camp these appeared to pass into mica slate, small scales of mica being disseminated through them.

We now proceeded to *Sagwára,* twelve miles north-east of the last. The country on leaving *Ghata,* became more open, and, though still uncultivated, was comparatively free from jungle. The line of march lay over the tops of the small hills which were still very numerous, and we had thus pretty extensive views of the surrounding country. It presented a waved, or rather mamillary aspect, and several small ranges of low ridge-shaped hills were observed. Mica slate, and mica slate approaching to clay slate, were almost the only rocks observed.

We next proceeded to *Jaríána,* a *Bhíl Pál,* sixteen miles from the last. The country was still completely studded with low rocky hills—for the first three or four miles mica slate preponderated, after this the hills were almost entirely composed of pure white quartz, in which occasional scales of mica were observed, but these were rare. This rock every where appeared at the surface, giving to the scene a striking and peculiar aspect, and were it not for a hot burning sun one would almost be inclined to believe that the country was covered with snow. No other rock made its appearance, except an occasional bed of mica slate of inconsiderable extent—many of the masses of this quartz were nearly transparent and approached to rock crystal, and others had a slight rose tinge. It was either compact or large granular, the concretions being about the size of a large bean: It occurred stratified, and, though the strata were not very distinct, the stratiform structure was sufficiently obvious. In dip and inclination it agreed with the other rocks seen. The whole surface of the country is covered with detached masses of this rock, and very frequently immense isolated blocks, of several yards in diameter, were seen topping the hills, and these, in many situations, were piled upon one another in a very fantastic manner. In the neighbourhood of camp was a group of conical hills, higher than the rest: these were formed of a micaceous clay slate.

Proceeding onward to *Jaitana*, in the *Udayapur* district, the country becomes more open, and plains of considerable extent are seen. There were still, however, numerous small rounded hills, while others assumed a conical form and others were ridge-shaped. The preponderating rocks were mica and clay slates, in which large beds of the white quartz occurred. *Jaitana* is six miles distant from *Jariána.*

We now marched to *Salúmbhar*, a walled town of considerable extent, belonging to one of the principal Omrahs of *Udayapur*, and situated eleven miles N. W. from the last. The mica slate, during this march, passed into gneiss, in which beds of granite, some specimens containing chlorite and hornblende slate were observed. From *Jaitana*, a range of hills were seen in the distance extending N. W. and S. E. *Salúmbhar* is situated at the base of this range, which is connected with the one which passes the *Dhábar*. The hills are generally ridge-shaped, and sometimes peaked, and those in the neighbourhood of the town are fortified.

In the nullah courses a very thick bed of kunkur, of a distinct rocky structure, and indistinctly stratified, was observed. The kunkur formation now becomes very abundant—it is differently modified in different situations—

situations—it is sometimes soft and friable, at others it is more crystalline—it occupies the highest situations as well as the lowest. This formation appears to me to be one of great importance, and, if examined on a large scale and described with minuteness might lead to very interesting results. When it rests upon the softer rocks, as claÿ slate, it is frequently seen penetrating into their substance, the water which held it in solution having percolated through the strata and deposited the lime in the form of calcareous spar in their interestices, so that these rocks at their surface are almost entirely converted into a calcareous rock, inattention to this circumstances may sometimes lead into error. Iron pyrites is very generally distributed through the mass, and rounded portions of various rocks are found imbedded in it.

We next proceeded to *Gingla*, a small village, twelve miles north west of *Salúmbhar*. On leaving the latter town, the country becomes very rocky and uneven, and exhibits the mamillary aspect so often alluded to. On the left hand the *Dhábar* range was seen stretching north-west and south-east, and other range of lower hills, running in the same direction, was seen on the right. These hills are generally ridge-shaped, some times peaked, and at others conical. The *Dhábar* lake was seen washing the base of the rough and craggy hills on the left. For the first half of this march gneiss passing into granite, generally of a red colour, with occasional beds of hornblende slate and quartz, was seen. The hornblende rocks then preponderated, and these and the granite rocks formed frequent alternations. *Gingla* is situated on a hill, composed of hornblende slate passing into greenstone, and in the neighbourhood are a number of small hills composed of a similar rock. The soil where these rocks occur is of a red colour, derived from iron which exists in them in great abundance, and the surface of the strata is covered with a thin brown crust, (carbonate of iron,) derived from a similar source. Occasional beds of gneiss, of a grey colour, small grained, and not stratified, occur in this formation. This gneiss is composed of dark coloured mica in minute scales, a felspar slightly tinged with red and translucent quartz. In the hornblende rocks, which are distinctly stratified, I observed a vein composed of felspar and quartz—the latter, clear and nearly transparent, the former, a pale reddish white, with perfect foliated fracture, and crystalline structure arranged so as to form a kind of porphyry.

We now marched to *Katáwar*, a pretty large town, with a fort, twelve miles north-west of the last. The *Dhábar* range was still seen on the left, and the country presented the usual mamillary aspect. The rocks observed were different modifications of granites, hornblende slate and chlorite slate—all these alternating with each other. The line of march in one situation approaches the range of hills, and a similar variety of rocks could be distinctly traced in their base and rocky slopes. The granitic rocks were, 1st, A gneiss of a greyish colour similar to that described at *Gingla*. 2d, A red granite, the principal ingredient a dark flesh red felspar—the quartz is in minute quantity and is translucent, and the mica of a dark color is in still smaller proportion. 3d, A reddish coloured gneiss. 4th, A rock, with the distinct structure of gneiss, of a greenish grey colour, in which the mica is replaced by hornblende; and 5th, A rock almost entirely composed of flesh red felspar, with a foliated fracture, and in which are imbedded nearly transparent crystals of quartz. The latter rock, except for the first two miles, within which the hornblende rocks were principally seen preponderated. It was distinctly stratified—strata highly inclined and dip towards north-east—mica is very rarely seen in it, and indeed is almost wanting. It may be said to form a variety of porphyry, but from its stratiform structure and the arrangement of its component parts, I prefer including it with the granitic rocks, in which series it ought certainly to be classed, perhaps, as a distinct variety, which may be called granitic porphyry. It passes into the flesh red granite before described, in which granite chlorite often occupies the place of mica, forming the protogine of Jurine. The felspar of the latter rock is uniformly of a darker red color than that of the granitic porphyry.

We next proceeded over a very bad road to *Thanna*, a *Bhíl Pál*, seven miles north-west of the last. The country presented the usual mamillary appearance of the lower granite tracts, but it was more broken and rugged than I had heretofore seen, and was traversed by numerous deep and narrow ravines. For the first three miles, the following rocks presented themselves ; viz. the felspar rock, which I have called granitic porphyry, which passes in some situations into gneiss and granite, both generally of a redish colour. A granite composed of pure *white granular felspar*—translucent quartz and silver colored mica, was also observed in small quantity. Through this last garnets were sparingly interspersed. These alternate with different modifications of hornblende rocks; viz. horn blende slate passing into greenstone slate and primitive greenstone—the alternating beds are from fifty to two hundred paces in breadth. We then reached the bed of a nullah, with rocky banks, composed of a formation exactly similar in appearance to the waved gneiss—it contains, however, no mica, its constituent parts being hornblende, felspar and quartz—the latter, in small proportion. I imagined at the time that this rock was a distinct grey gneiss, and picked up several specimens of it as such. It formed now the preponderating rock in which beds, but not of great extent, comparatively speaking, of hornblende slate and greenstone were observed, beds of red granite, and in one or two instances, of chlorite slate were also seen.

The above described rock exactly resembles the close grained grey gneiss. It had a waved appearance, and it was only on reaching camp, and examining my specimens that I discovered its true composition. It may be called scienitic gneiss. It was distinctly stratified and dipped towards the N. E. This formation is continued for several miles in the direction of the Residency at *Minta*, at which place I arrived next day. The geology of the last march I shall not enter into at present, as I propose drawing out a " sketch of the geology of the valley of *Udayapur* and its neighbourhood," in which this portion of the country will be included.

In conclusion, I would again call your attention to the regularity of the gradation observed from the rocks seen on leaving *Birpur* to those in the neighbourhood of *Udayapur*. They pass into each other by almost insensible degrees, so that it is often difficult to say, in which class particular specimens ought to be included. The granitic rocks,—except the very large granular variety of *Pandua*, which I have supposed to be a very old granite—are, generally speaking, small grained, or intermediate between small and large.

These remarks, such as they are, I do myself the pleasure of forwarding to the Physical Committee of the Asiatic Society, and I have to regret, that the season of the year at which I travelled; viz. during the hot winds, prevented me extending my observations so far as I could have wished. This circumstance must plead my apology for the imperfect nature of this communication. I have avoided entering into any details connected with the character, &c. of the inhabitants of the country through which I have passed: this would have extended my paper to an undue length: this, however, I must say, that I have experienced nothing but civility from the rude and barbarous tribes among whom I have travelled, and, though the names of *Bhíl* and *Coleah* have always been associated with those of plunderers and robbers, I have met with more attention from these very tribes, than I have ever experienced in other parts of India. The chiefs (9 *Omtí's,*) of their *Páls,* frequently visited me—they appeared to have a great deal of curiosity, examined every thing about my camp—asked various questions about the uses to which they were applied, and on the whole, I was much pleased with the rude inhabitants of this wild and mountainous portion of *Hindustan.*

The route by which I have marched is not the common one, I have no hesitation, however, in recommending it to travellers who may be proceeding from *Bombay* to *Nímach,* as by far the shortest and the best. From *Baroda* to *Nímach,* via *Bírpur* and *Salumbher,* there are only eighteen or nineteen ordinary marches.

The accompanying section of the strata from *Baroda* to *Thanna,* I do not offer as perfectly correct; it will serve, however, to give a general idea of the geology of the tract in question. In a plan on so small a scale, I could only indicate the rocks which preponderate in particular situations, and no attempt has been made to lay down the beds of other rocks with which these are associated, and with which they frequently alternate.

V.

ON THE
DIAMOND MINES OF PANNA
IN
BUNDELKHAND.

By CAPTAIN JAMES FRANKLIN,

First Bengal Cavalry, M. A. S.

(WITH A MAP.)

The geological position of the matrix of the diamond, being still a question in the history of that gem, the following notice on the diamond mines of *Panna*, will not, I trust, be unacceptable.

Report says, that they were first[*] discovered in the time of Raja CHITRASÁL, who ruled at *Panna*, in the reign of the Emperor AURANGZEB, but that period being a troublesome æra in the annals of the *Bundelas*, it is supposed, that they were not efficiently opened, until the time of his grandson SUBHA SINHA.

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[*] Their discovery is attributed to a Devotee of the *Mehdivi* sect, who established his doctrine at *Panna*, in the time of Raja CHITRASAL, or about A. D. 1680-90, I doubt this statement, but I cannot arrive at satisfactory proof of their previous discovery. Mr. MAWE dates the discovery of the mines of *Brasil* about the same period, and Dr. HEYNE has a similar account of some of those of *Golconda*, but TAVERNIER says, that the Mogul diamond was found at *Color*, not far east of *Golconda*, A. D. 1550.

BOETIUS DE BOOT published his treatise " De Lapidibus et Gemmis," A. D. 1609, and points out the diamond mines of *India* and *Malacca*—and in fact, it appears, that the diamond has been found in India in all times, since the days of PLINY, and, perhaps, long before.

Their situation is peculiar, being confined to a small portion of the great belt of sandstone which extends from *Rotásgerh*, through the provinces of *Boghélkhand* and *Bundélkhand*, until it is finally covered by the overlying trap of *Malwa* and *Ságar;* this, however, is but a small part of the extent of this formation, for the break at *Rotásgerh* is merely an hiatus occasioned by the original current of the *Soan* valley, which doubtless swept away every vestige of this rock, until its force was turned aside by the projecting points of the *Vindhya* range, near *Monghir*—after which, in the *Rájmahal* hills, the sandstone again appears as before—and from that point it may be traced throughout the whole of the peninsula; it is the depositary of the diamond at *Panna*—and I have, no doubt, that the rock mines both of *Sembhelpur* and *Banganpilli*, though far asunder, will ere long be found to belong to the same formation; in the mean time, the following facts which have fallen under my own observation, on my route from *Belári* to *Ajayagerh*, may serve to identify the class and character of the rock which contains the matrix of the diamond of *Panna*.

The *first part of the route (or from *Belári* to *Ajayagerh)* crosses the most lofty portion of the sandstone belt, usually called the *Bandair* hills—which, without exception, is entirely composed of argillaceous sandstone, either mottled or streaked—and opposite to the village of *Piperiya*, below the Ghat of that name, I observed the sandstone reposing on beds of slaty marl.

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* See the map which is appended to my paper on Geology, Art. 2d, of this volume; also the description of these hills in that article.

Having descended the *Bandair* hills by the Ghat of *Piperiya*, I came upon the second range, which like the former, is also composed of sandstone, but the surface of its plateau being covered with a stratum of lias limestone, the sandstone can only be traced in the beds of rivers, or in small protruding elevations, until it emerges from beneath the limestone and forms the counterscarp of the *Panna* hills, where it is variegated and friable, and the marly slates are again visible in the hills which overlook the town of *Panna*.

The lowest portion of the range, or that which is called *Bindáchal*, is the peculiar habitat* of the diamond, for it is not found in any other part, except on the platform of this range, or on the counterscarp of the second, and it is proved by the waterfalls, that this range also is entirely composed of sandstone † For instance, the cascade of the *Ranj* river shews a series of sandstone interstratified with slate clay three hundred and ninety feet thick. All the other waterfalls present similar appearances, and that of the *Bágin* river, penetrating deeper than the rest, exhibits a fine section; here the sandstone‡ is distinctly interstratified by a succession of layers of slate clay, the uppermost of which having a marly base is thickest, and the descending strata becoming more indurated, containing more mica, and gradually diminishing in thickness, dwindle away finally into mere partings, and in their progress to this attenuated state, they assume characters so various, that in some instances, it is difficult to distinguish them from the older schists. The sandstone also changes, gradually becoming *silicious, and at the bottom it closely resembles some varieties of quartz rock, but the horizontal position of the beds is constantly preserved, and in all the glens, particularly in that of the *Bágin* river, black bituminous shale crops out from beneath the sandstone. I excavated this shale to the depth of six feet—but having no other means than such as I could procure on the spot, the influx of water soon overpowered my operations. I found, however, that the bituminous quality of the shale increased,—fragments of it, throwing out strong shoots of flame when ignited, and I was disposed to think that coal was not far distant.

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* The diamonds found in the glen of the *Bágin* river are transported diamonds, they are not, therefore, an exception to this rule.

† See the map appended to this paper.

‡ The sandstone of the *Bindáchal* hills rests as on a point d'appui upon a low ridge of syenitic granite, which has, probably, saved it from being swept away. The bases of the forts of *Kálenjara* and *Ajayagerh*, are of this rock, and are merely capped by sandstone. The same may be said of the scarp of the great range, but if the granite ridge be crossed by entering into any of the glens, the sandstone will be seen to be at least four hundred feet thick after the ridge is passed.

I have ventured to call this formation *new red sandstone*, considering it in the same light as the series of rocks so termed in *England*, and it would appear, that this denomination is in some measure corroborated by other facts, in other portions of the same range of hills, but principally by the proof of its saliferous nature. It has been †shewn, that at the village of *Kattra*, the soil is impregnated with salt, which is there, and in many other adjacent villages, extracted by the native process of lixiviation, such is the case also on the banks of the *Tons* river, and ‡Mr. STIRLING, who published an account of the diamond mines of *Pánna*, remarks, that salt abounds in the soil at the foot of this range, opposite *Allahabad*, and between that place and *Mirzapur*. These facts, therefore, together with the general horizontal position of the beds, the existence of lias limestone reposing upon them, the distinct interstratification of a series of slate clay, and above all, the cropping out of bituminous shale from beneath the whole mass, would appear to justify the use of the term which I have applied.

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* I observed the same circumstance in the waterfall of *Bowta*—See Art. 2d of this volume.

† Art. 11th of this volume.

‡ See Oriental Quarterly, No. — Page — Mr. STIRLING did not visit any other mines than those in the immediate vicinity of *Panna*; and Dr. HAMILTON, who has published an account of these mines in the Edinburgh Philosophical Transactions, vol. 1, distinctly says, that he did not even go so far as *Panna*, and could not have seen any other than a few superficial mines, at the top of the *Bisramganj* Ghat.

I have been thus prolix, because it is of importance that I should be clearly understood with regard to my nomenclature, and, if I am wrong, my own description may, perhaps, serve to correct my error. Having thus premised, I shall now proceed to give as brief a description as I can of the mines in question.

The natives describe the mines by using the terms *chíla*, or superficial, and *gahira*, or deep, and the matrix they call *madda;* the rocky matrix of the deep mines is always a conglomerate, and, if it is a gritstone with a silicious cement, and its pebbles are of ancient rocks, and waterworn, it is termed [*]*pakka*, or mature; but if the cement is argillaceous, and its pebbles are of more [†]recent rocks, it is then called *kacha*, or immature; the matrix of the superficial mines is universally called *Lálkakru*, or red ironstone gravel, mixed with ferruginous sand or clay. This gravel is waterworn and sometimes quite rounded like swan shot, and when found in the [‡]fissures and interstices of the upper sandstone, it is mixed with ferruginous sand, but on the other hand when imbedded in ferruginous clay, it is usually found covered with vegetable soil and reposing upon slaty[§] marl;—sometimes, however, it is surmounted by a stratum consisting of particles of common *kankar* imbedded in yellow clay, which occasionally mingling with it, forms, another *description of matrix which being calcareous, is called *hadda;* the diamonds of the glen of the *Bágin* river, have evidently been transported thither from their native beds, and in all probability the gangue in which they now rest in the basin of the waterfall, greatly resembles the cascalho of the Brazils. or that of *Sambhelpur*, in Southern India.

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[*] As at *Panna*, *Kamaríya*, *Brijpur*, &c.

[†] As at *Sákeriya* and *Udesna.*

[‡] As on the counterscarp of the *Panna* hills.

[§] At *Panna* and *Kamaríya.*

The *pakka*, or rocky matrix, is very limited, stretching generally from *Kamaríya* to *Brijpur*, along the course of the *Bágin* river. It is excavated at *Kamaríya, Bijipur, Bargari, Myra* and *Etwa;* there is also a small deposit of it near the town of *Panna*, but at *Brijpur*, from the effects of denuding causes, it lies at the surface, and a very satisfactory section of it is laid bare in the bed of a small rivulet about one mile west of the village, where it appears to be a gritstone, composed of white quartz gravel, cemented by silicious matter, and containing rounded pebbles of quartz, jasper, hornstone, lydianstone, &c. Thus it forms a conglomerate, which passes by gradual transition into silicious sandstone. It is readily distinguished from its associated rock, differing greatly from it, in as much as the sandstone in which it is found, has a martial argillaceous cement, and closely resembles that which forms the upper layer of the cascade of the *Bágin* river.

Kamaríya Mines.

The most noted mines of this description of matrix are those of *Kamaríya* and *Panna;* at the former place they are on an average about fifteen feet deep, and in one which I examined, the beds of slaty marl were two feet below the surface, a thin stratum of red ironstone gravel imbedded in ferruginous clay, and vegetable soil, were their only covering; they differed in no respect from those of *Piperíya* Ghat, they were marly, slaty, slightly micaceous, interstratified with thin laminæ of sandstone, and associated with calcareous slates, which were dendritic between their partings, and although their general colour was bluish green, or greenish grey, yet there was a sufficient mixture of red to characterize them; they were about twelve feet thick, and immediately below them was the rocky matrix of the diamond.

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* At *Bangla, Bakhtapur, &c.*

The conglomerate is here as at *Brijpur*, a gritstone containing pebbles of quartz, both white and *green, jasper, hornstone, lydianstone, &c. and it is worthy of remark that when the green quartz pebbles abound, it is considered a good sign, and so also when the gritstone is slightly ferruginous, the matrix in there mines reposes on compact sandstone.

Panna Mines.

The mines of *Panna* are of the same kind: here also the stratum beneath the vegetable soil is red ironstone gravel, below which are beds of slaty marl, better characterized if possible than those of *Kamaríya*, then follows the †diamond matrix, which differs in no other respect from that of *Kamaríya* or *Brijpur*, except that it appears to contain a little more ferruginous matter; its pebbles are the same, its cement the same, it has the same peculiarity of containing green quartz nodules so highly esteemed as an augury by the natives, and its floor is of the same description of sandstone.

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* The green quartz is exceedingly brittle and splintery, the natives call it *Kánchiya*, or glassy.

† It is worthy of remark that both this matrix and that of *Kamaríya* inclose fragments of schist, which M. CHARPENTIER calls schiste argilleux terreux *jaunâtre* (see his Essai sur les Pyrénées, page 297.) I have seen this rock in situ at *Betharam*, at the entrance of the valley of *Barej*, a small specimen of which accompanies this paper, but I have not as yet been able to trace it in situ in India. At *Betharam*, it is on the summit of a hill, the base of which is formed of Ophite, a rock of the trappean family, so named by M. PALASOU—it has also a great resemblance to burnt clay, so named in Wernerian collections of minerals, as for instance in that presented to the Society by the late Dr. ABEL.

These mines vary in depth from twenty to fifty feet, and owing to the stratum of the matrix being thinner (sometimes scarcely a span thick,) they cannot be worked laterally as at *Kamaríya*, they are therefore more expensive, but their produce is said to cover the outlay and yield a profit. They are consequently esteemed, and hold a reputation nearly equal to those of *Kamaríya*.

Sakeríya Mines.

The *kacha*, or immature matrix, is excavated at the villages of *Sakeríya* and *Udesna*, both situated on the counterscarp of the *Panna* hills. It contains rounded pebbles of quartz, jasper, lydianstone, &c., but with these are mixed more recent pebbles of white sandstone. It contains also much white quartz gravel, called by the natives *detla*, but the cement of the conglomerate instead of being silicious is a yellowish white clay, soft and plastic when in its natural bed, but capable of acquiring the consistency of mortar when exposed to the atmosphere, and when it contains ferruginous matter it is considered a good sign. The quartz pebbles are of the fat and greasy variety, and the green kind so much esteemed in the rocky matrix, is here entirely wanting.

A shaft near *Sakeríya* which I examined, pierced through the following beds; 1st, eight feet vegetable soil; 2d, eight feet *píri matti*, or common *kankar*, imbedded in yellow clay; 3d, four feet *lálkakru*, or red ironstone gravel in ferruginous clay; 4th, two feet *detla*, or white quartz gravel; next followed sandstone, and then the *kacha* matrix; The thickness of the *detla* stratum is here considered a matter of augury; if it is too thick it augurs ill, as it is then supposed that the stratum of *madda* will be correspondently thin, or wanting altogether;—It ought not to exceed two feet.

Udesna Mines.

Near the village of *Udesna,* the same kind of matrix underlies *laterite, there called *macha;* the great abundance of ironstone gravel and ferruginous matter strewed over this part of the country necessarily produced in former times, and no doubt still continues to produce, a great quantity of oxide of iron, which being washed away, and held in solution by the minor streams, has been gradually deposited in the channel of the *Ranj* river until it is now about ten feet thick, and immediately below it are the beds of *detla* and sandstone, and the matrix as above mentioned. This matrix does not require to be broken, the clay is easily separated by washing, and the expense of working the mines is consequently lessened, but still they are not considered so certain in their return as those of the rocky matrix.

Superficial Mines.

The *chila,* or superficial mines, are to be found in every part of the diamond tract, excepting only a circuit of about five miles from the cascade of the *Bágin* river, where it appears that denuding causes have swept them away and all their contents into the glen of that river. Their matrix is always red ironstone gravel in ferruginous sand or ferruginous clay. Their geological position with regard to the descending series, appears to be remarkably well defined, for they are actually to be found on the verge of two *cascades, having 400 feet of sandstone beneath them; when this matrix fills the fissures and interstices of the upper sandstone, angular fragments of the rock are mixed with it, the corroding influence of the oxide of iron appearing to have detached them as well as to have desintegrated and oxidated a portion of the rock so that the gravel and fragments are imbedded in sand so highly ferruginous that it resembles the rust of iron; but when on the other hand it is imbedded in ferruginous clay, it contains no fragments of sandstone, and is constantly found overlying slaty marl or sandstone, or *detla*, as in the instances above mentioned; with regard to the ascending series its geological position seems also to be well defined, for if the two strata of red ironstone gravel and *kankar* occur together, as they do at *Sakeríya*, it always underlies the †calcareous bed, and their line of separation is distinct so that when they happen to mingle as at *Bangla*, the matrix acquires a new name, and is then called *adda*.

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* The laterite is an aggregate of ironstone gravel cemented by an argillo furruginous cement, it therefore somewhat resembles pisiform iron ore; the great mass must have been formed by diluvial agency, but it appears to accumulate by alluvial action also—for the natives assert that the stream is reddened in the rainy season;—as there has not, however, been any sensible increase of it in the memory of man, I conclude that its alluvial accumulation must be very imperceptible.

These mines rarely exceed five or six feet in depth, and are often much less; with regard to their produce I am inclined to think that they are very precarious, notwithstanding some of the largest diamonds have been found in them; it is common to hear complaints of having found nothing for many months, and to me they appeared like a lottery in which there are a few prizes and many blanks—they have an advantage in requiring little or no outlay, and are consequently wrought by all classes, but it is not unlikely that more capital has been sunk in them in the shape of labour than has ever been returned.

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* On the verge of the cascade of the *Ranj* river near *Rámpur*, and on that which is near to the village of *Bakhtapur*.

† The fact of the production of laterite in the bed of the *Ranj* river, and the circumstance of ironstone gravel underlying, and consequently, preceding common *kankar*, are useful facts in Geology.

The diamond is occasionally, though very rarely, found on the surface, nor is it improbable that some lucky chance of this kind may have led to the discovery of the mines.

Mines of Transported Diamonds.

The above is a brief account of all those matrices of the diamond in the *Panna* district, which fall under the denominations of *madda, lál-kakrú*, or *hadda ;* but there are others where the gem is found in deposites with which it appears to have been swept away from its native beds, as at *Majgoha* and in the glen of the *Bágın* river; the mines of the former place are peculiar and require separate mention, but in those of the glen, the diamond is found under rocky debris, both on the banks and in the bed of the river, and also in the basin which receives the cascade: its matrix in this state, is a confused mixture of red ironstone pebbles, angular fragments of sandstone, and pieces of common *kankar*, heaped together in ferruginous sand or clay, the detritus in fact of its original gangue; and the mines of course have a great resemblance to the superficial mines above-mentioned, but they are said to be rather more productive, and there is great reason to believe that the basin of the cascade has never yet been emptied or excavated except to a trifling extent.

Majgoha Mines.

The mines of *Majgoha* are in the western part of the diamond tract, and they may properly be called its western boundary; they are situated in a hollow resembling an inverted cone, which appears to have been excavated by the same process (more powerfully applied) which scooped out those resemblances to it in miniature, which are observable in the rocky beds of rivers, the diameter of the vortex is about 100 yards, and its depth (I presume) cannot be less than 100 feet; on its periphery, superficial mines are wrought in sandstone, but the cavity of the chasm is filled with green mud, containing calcareous matter, such as I can find no apt similitude to, except by supposing it to be the abraded matter of the same marly slates as those which occur in the mines of *Panna* and *Kamariya*, here deposited en masse, and there in slates; this of course is mere conjecture, but if the vortex has been formed as I suppose it to have been, the matter could not in that case have acquired a schistose form; be the facts of the case however what they may; this singular deposite fills two-thirds of the chasm, and at the top it has a thick crust of calcareous spar, which is indistinctly stratified, and contains portions of the green mud between its laminæ.

The diamond is rarely found in the calcareous crust, its habitat being in the green mud, and it is believed by the natives, that the deeper a shaft descends, the richer is the produce; but although they are aware of this circumstance, their ordinary means have never enabled them to descend lower than fifty feet, the water at that depth overflowing their works, and compelling them to desist: this deposite, therefore, and that of the basin of the *Bágin* river, appear to be two instances in which superior means might be employed, with effect, and perhaps with profit.

Mode of washing and searching the Matrix.

The mode of washing and searching is the same in all the mines, the rocky matrix alone requiring to be broken; it is first thrown into a trench with water and shoveled and trod like mortar, and as the object is to wash away the clay, fresh water is thrown on and poured off repeatedly until the fragments are sufficiently cleansed, and as a final purification they are sifted on fine baskets which completes the operation of washing, they are then spread in a thin layer on a smooth floor plastered with clay or cow dung, and when dry the whole is passed under the hand, and searched three several times, after which the fragments are thrown aside.

Reproduction of the Diamond

The circumstance of diamonds being frequently found amongst these fragments after they have been thrown aside, has, perhaps, given rise to the idea of their reproduction, and I was anxious to obtain the opinion of experienced natives on this subject: they admit it only in one instance, viz. at *Majgoha,* and even there, it is always ascribed to the spiritual agency of the founder of the *Mehdivi* sect, to whom those mines belong, but their more rational opinion is as follows, which I will give as nearly as possible in the words of my communicant. " The object of washing is to free the rocky fragments from clay, and particularly to cleanse the diamond, so that it may readily be distinguished in the operation of searching, but with all our care we cannot always succeed; small diamonds frequently retain their covering, and thus elude our search in the first scrutiny, nor can they be discovered afterwards, until the coating which concealed them is worn away; hence it happens that diamonds are found amongst fragments which have been searched and thrown aside, but it is observable that small diamonds alone are so found, and that they rarely exceed the weight of half a troy grain."

With regard to *Majgoha* I am inclined to think that the above opinion applies with greater force. The matrix of these mines contains calcareous matter, and it is no easy attainment to wash away a calcareous incrustation by using water alone, whenever therefore, such an occurrence takes place, the diamond might not only elude a first search, but a series of searches, and even for a series of years, until the coating which enveloped it, was worn away.

Description of the Diamonds.

The diamonds of the *Panna* mines may be classed, according to the following arrangement, using native denominations: 1st, *Lilwaja*, transparent, colorless, having no tinge except the azure which is reflected in a drop of distilled water, it is so scarce that only one specimen was to be found in the town of *Panna*.

2nd. *Banspati*, *Motichar*, *Ghiya*, or *Maska*: these kinds are common, the first has a greenish tinge, the second is also greenish, but varies to a pearly cast; the third is yellowish and of a greasy or resinous lustre, as its name implies;—the crystalline form of this class is very distinct, exhibiting frequently the regular octahedron as perfect as if it had been shaped by an artist, the dodecahedron is also common, and so is the spheriodal, arising apparently from the convexity of its faces, and the obtuseness of its edges the average price of this class is thirty **Srinagari* rupees, for diamonds of one *retti* weight 35 for two, 40 for three, 45 for four, and 50 for those of five *retti* weight.

3d. *Sambarra* and *Charchara*: these are they which have given rise to the belief that the *Panna* mines produced only table diamonds, the specimens I saw were quite irregular in their crystalline form, appearing as if they had been broken by a violent blow, but they invariably cleave into thin tabular laminæ, and as they are generally of a good water, and sell for a low price in comparison with the others, the *Panna* jewellers appear to find it more profitable to work them up, by setting them in rings or other ornaments; their one *retti* price is twenty rupees, increasing according to weight as above stated.

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* The *Srinagari* runees is about ten per cent. less in value than the Sonat rupee, consequently it is about fourteen and a half or fifteen per cent. less than the Calcutta Sicca.

4th. *Bengala pashmi, Píra* and *Matta:* these are yellowish green, yellow, and clove brown, and their crystalline form is multiform, the price of the one *retti* gem is fifteen rupees, increasing as above.

5th. *Rekatberar:* this is the rose coloured variety, its crystalline form is also multiform, it is not esteemed, and its single *retti* price is twelve rupees.

6th. *Kála, Garas,* or *Jalidar:* the first is black or very dark brown, and the second as its name implies, includes all diamonds that are flawed or appear to continue filaments like a spider's web: these varieties are here termed *Kaffiya,* or scum, but in *England* they are called *bort,* and there they are used in the arts for diamond dust to an extent unknown in this country, their price varies according to the size of the stones: but as they seldom, if ever, exceed one *retti* weight, the worst kind may be purchased for eight and the best for ten rupees the *retti.*

The above list contains the principal names classed according to their relative value, but there are others, apparently founded on fancy alone, a recital of which would embarrass rather than throw light on the subject; the prices also must be considered variable, a purchaser coming suddenly into the market would as infallibly occasion a rise, as a deficiency of demand would create a depression, a purchaser therefore should fix himself on the spot, and make his purchases gradually, by so doing, he would at least save the profits which now go to the merchants of *Benares*.

Revenue of the Mines.

The revenue of the mines is divided among the Rajas of *Panna*, *Banda*, *Chircari*, and *Jaitpur*, but by far the largest share belongs to the former. According to my calculation the *Panna* division amounts to about 26,000 Rupees per annum, but according to Raja PERTAB SINH, who is the effecient manager of the *Panna* state, it is 30,000 Rupees, and as his authority is likely to be nearer the truth than mine, I do not hesitate to adopt it; this revenue is derived from a *tax, originally fixed at one-fourth of the value of all diamonds found in these mines below a certain weight, which, I believe, was rated at eight *rettis*, but the tax now levied is said to exceed this rate, and on diamonds above the eight *retti* weight there is no stipulation, taking therefore the aggregate of the *Banda*, *Chercari* and *Jaitpur* shares, as equal to a fourth of the revenue derived by the Raja of *Panna*, it will not be too much to suppose that the produce of the mines amounts to about 1,20,000 Rupees per annum.

I have now detailed with the utmost fidelity all the circumstances relating to these mines as they occurred to me at the time I examined them, and have endeavoured to throw into my narrative as much perspecuity as the subject is capable of; still, however, the diamond is too important a mineral to be passed over in a hasty manner, and I trust I shall be excused if I here indulge in a few general observations.

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* The tax of 25 per cent. was fixed in the best days of the mines, when the produce was greatest. They are now, however, on the decline, and the natives are quite aware of the circumstance; the superficial extent of the *pakka* matrix appeared to me to be traceable, and consequently the question of its quantity falls within the range of reasonable calculation, whether the natives have drawn their conclusions from this view of the case, or whether they are influenced in their judgement by experience, arising from the natural result of their draughts from an exhaustible scource, I do not know, but to me it appeared, that these mines by the employment of a given force, might be exhausted within a given time, and that there is no hope of finding diamonds below the bed of the *pakka* matrix.

General Remarks.

1st. It was formerly supposed that diamonds were always found at the [*]same level above the sea, and it still remains to be proved whether or not there is any truth in the hypothesis, the following barometrical heights are deduced from actual observations made by myself.

Kacha Matrix.

Source of the *Ranj* river near *Udesna*, ...	1496 feet.
Floor of the mines of *Sakeríya* and *Udesna*, ...	1470 ,,

Pakka Matrix.

Floor of the mines near *Panna*, ...	1300 feet.
Bed of the *Ranj* river due east of the above, ...	1300 ,,
Top of its cascade near *Ranipur*, ...	1240 ,,
Source of the *Bágin* river near *Urki*, ...	1420 ,,

Floor

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[*] This hypothesis can only apply to diamonds in their native or rocky beds, and does not of course refer to transported diamonds which are found at various levels, but if the rocky matrix is universally confined to sandstone of the same era, it is not unlikely there may be some truth in it, at least in India, for instance, the rock mines of *Banganpilli* appear to correspond pretty closely with those of *Panna*, and Captain CULLEN (Madras Lit. Trans.) says, that "the route across the plain between the nalla malla range and the table land at *Banganpilli*, is about 800 feet above the sea;" now the town of *Banganpilli*, from its position with regard to two rivers, (the *Kund* and the *Suru)* which unite in that plain, must be still higher, and Dr. HEYNE says, it "is built at the foot of a low ridge of hills—from 100 to 200 feet perpendicular height on which the diamond mines are situated." Dr. HEYNES estimate of the height of the diamond ridge is conjectural, and may, as is often the case, in estimates of height made by the eye be rated too low—upon the whole, therefore, I think, there is reason to conclude, that the diamond bed of the *Banganpilli* mines is at least 1100 feet above the sea.

Floor of the mine of ***Kamariya***,	1380	feet.
Bed of the ***Bágin*** river due south of them,	1380	
Floor of the mines of ***Brijpur***,	1260	
Bed of the ***Bágin*** river exactly opposite,	1250	

Matrix swept away.

Top of its 1st cascade,	1120	feet.

Transported Diamonds.

Bottom of 1st cascade,	900	feet.
Bottom of 2d cascade,	700	„

From this list it would appear that the rock matrix of the diamond in the *Panna* mines has been swept away at an elevation of 1100 feet, and that its lowest position in situ is between 12 and 1300 feet above the sea.

2d. The contracted limits of this diamond tract has already been mentioned, as a peculiarly striking circumstance; the same kind of sandstone as that in which the diamond is found, extends far beyond those limits and why does it not contain diamonds also ? to this question I can only reply by the following explanation; *on the north*, the scarp of the ***Bindáchal*** hills rests as a point d'appui on a low ridge of sienitic granite and the plains of ***Bundelkhand*** exhibit primitive rocks throughout—therefore excepting transported diamonds, none can be expected in that quarter; *on the south*, lias limestone stretches along the outline of the counterscarp of the second range of hills— and here again (excepting the diamonds of the counterscarp) none are ever found—being perhaps buried by the overlying limestone; *on the west*, the sandstone becomes thinner, being often little more than a mere capping; the conglomerate form is also frequent, but in the diamond tract it is remarkable that there is no other conglomerate than that which contains the diamond; moreover, black bituminous shale rises to the surface near the village of *Sahigerh*, though in the diamond tract I have never seen it with less than 400 feet of sandstone resting upon it; *on the east*, the sandstone continues pretty much the same, and I cannot offer any satisfactory reason why diamonds should not be found east of the *Cheyla Nadí*, which at present is considered to be their eastern boundary.

3d. I have endeavoured to show that the rocky matrix of the diamond of *Panna* is situated in sandstone, which I imagine to be the same as the *new red sandstone* of *England;* also, that (if the transported diamonds are excepted,) there is at least 400 feet of that rock below the lowest diamond beds: and further, that there are strong indications of coal, underlying the whole mass; how far this may agree with the *geological position of the same description of mines in Southern India, will best be seen from the following extracts.

As far as I understand, Dr. HEYNE, in his tracts on India, pages 103-4, the hills which surround the rock mines of *Banganpilli*, are composed of slate clay, and his account of them reminds me much of *Panna*, he says, " they are straight at top, and usually level for some extent," so that even villages are built on them—he says also, that " the water of the wells is brackish," a strong indication of their saliferous nature, and further " that the country about *Banganpilli* is sandy and stony, and that the stones are chiefly conglomerates, composed of silicious materials."

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* Mr. MAWE says, " the diamonds of *Brazil*, like those of India, are found in a loose gravel, immediately incumbent on the solid rock, and covered with vegetable mould and recent alluvial matter. This gravel consists principally of rounded quartz pebbles of various sizes, mixed with sand and oxide of iron;" in some parts which he visited, he says further, " the gravel is cemented by means of the oxide of iron into a considerably hard conglomerate forming rocks and low hills, in the sides of which are water-courses produced by torrents during the rainy season, in these hollows, diamonds are not unfrequently discovered," and he concludes by saying, that " if this conglomerate is not the real matrix of the diamond, its true geological situation is unknown." (MAWE on Diamonds.) The matrix of Mr. MAWE appears to resemble that of the transported diamonds of the *Panna* mines, and as far as I can judge by description, it seems still nearer to resemble those of Southern India.

With respect to the rock in which the matrix of the diamond is found, his description is as follows—" the solid rock of the hills (which by the bye is not quite destitute of diamonds,) is an aggregate, consisting chiefly of a coarse grey hornstone, with rounded pebbles of the same species, but of a fine variety of stone, or of jasper, of different colors; at some depth, this rock becomes ferruginous sandstone, the grains of which are finely cemented together, and this kind of stone usually forms the roof of the floor of the mines; the floor is generally of a reddish brown color with shining particles, and strikes fire with steel;" again he says, through this solid rock the miners must make their way before they arrive at the diamond matrix.

Dr. Voysey's account of these mines is " that the diamond matrix," in its rocky state, is " a sandstone breccia;" it lies under " compact sandstone, differing in no respect from that which is found in the main range, it is composed of a beautiful mixture of red, and yellow jasper, quartz, chalcedony and hornstone, of various colours, cemented together by a quartz paste, it passes into puddingstone composed of rounded pebbles of quartz, hornstone, &c. cemented by an argillocalcareous earth, of a loose friable texture, in which the diamonds are most frequently found."

The apparent discrepancy in these accounts is not irreconcilable—but Dr. Voysey is most distinct in his description, he says that the rock under which the diamond matrix is found, is compact sandstone, and that it differs in no respect from the sandstone of the main range, he did not see the floor, but Dr. HEYNE appears to have done so; and, if I understand him right the floor is sandstone also, for he says, (page 105,) that the diamond bed is of the same nature with the rocks both above and below it, but is distinguished from them by its superior hardness, and that the floor is so hard that it strikes fire with steel, a peculiarity which equally applies to the *Panna* mines.—Dr. VOYSEY arrived at the following conclusions.

1st. That the matrix of the diamond in the mines of Southern India is the *sandstone breccia of the "clay slate formation."

2d. That those found in alluvial soil are produced from the debris of the above rock, and have been brought thither by some torrent or deluge, which alone could have transported such large masses and pebbles from the parent rock, and that no modern or traditional inundation has reached to such an extent.

3d. That the diamonds found at present in the bed of the rivers are washed down by the annual rains.

I cordially agree with Dr. VOYSEY in the general result of his conclusion, because I am satisfied that the same circumstances are applicable to the mines of *Panna*, but I nevertheless differ from him in two points; 1st, I could not trace any likelihood of diamonds being washed away by any natural causes now in operation, such as the annual rains—they are, in general, too deeply covered with soil, even in their most superficial beds to admit of this conclusion, and such only as might have accidently laid on the surface could be so transported.* 2nd, I cannot agree with his nomenclature with regard to † "clay slate formation," because he himself says, that in using the term clay slate, he does not mean the *Thonschieffer* of WERNER, which is the only recognizable term for that rock according to the Wernerian system, but excepting these two points, I have found great accordance with his result, and am happy in having it in my power to express it.

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* As it appears from his description that the pebbles are rounded, perhaps the term conglomerate, or puddingstone, would be better than breccia, at least it would be more in accordance with terms already recognized

4th. There is another circumstance to which I must advert, but I do so with diffidence and under a hope that it will be considered merely conjectural. Dr. BREWSTER supposes the diamond to have originated like amber, perhaps from the consolidation of vegetable matter, and that it gradually acquired its crystalline form, by the influence of time and the slow action of corpuscular forces: the late Dr. VOYSEY adverted to this opinion in his account of the diamond mines of Southern India; and on the occasion of publishing an abstract of that paper in his Journal of Science, Dr. BREWSTER observed that he saw no reason to alter his opinion: now as the rock matrix of the diamond of *Panna* appears in some respects, though not altogether, to resemble that of *Banganpilli* in Southern India, there would seem to be little chance of my conjecture being useful, still however as every opinion regarding the origin of this fine mineral is as yet theoretical, I will not withhold what occurred to me on this subject, though I again repeat that I offer it with great diffidence.

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[*] My meaning with regard to this point of difference is, that I consider the transported diamonds to have been chiefly swept away by diluvial action, and that alluvial agency must have been very inconsiderable, though I do not deny its partial influence.

[†] It has occurred to me on reading Dr. VOYSEY's paper on the diamond mines of Southern India, that the rock which he has termed clay slate, may, perhaps, be the slate clay of the English geologists, or the secondary argillaceous schists or shales of Dr. MACCULLOCK, which are associated with secondary sandstone; Dr. HEYNE mentions slate clay as being the chief constituent of the surrounding rocks in the *Banganpilli* mines.

The theory of Sir JAMES HALL on the consolidation of strata frequently recurred to me when examining the sandstone in which the diamond is found; I thought that I could discern much in favour of it, and particularly in the gradual changes of its nature, from the lower to the upper strata; now if the principle of this theory is admitted to be correct and applicable universally, it follows of course that it must be applied here; and then it may be questioned, how the diamond was preserved, under that *degree of heat which must have been necessary to form its matrix the gritstone? In answer to this objection I suggest, that, the circumstance of calc spar occurring in trap rocks is somewhat analogous, and if it is admitted that compression under the weight of strata, and a superincumbent ocean, had the effect of resisting the expansion of its carbonic acid and constraining it to continue in combination with lime, might not the same principle be reasonably enough applied, to account for the preservation and detention of the elements of the diamond in the gritstone? and again, should it be further shewn that crystals, such as those with which we are familiar in nature, may be produced by slow cooling or other processes according to the above theory, may we not look to it also, to account for the crystalization of the gem?

This conjecture rests upon the truth or fallacy of Sir JAMES HALL's theory, or, on a modification of it, and when this theory is considered as the result of long and patient experiment, and the high reputation of its author is taken into account, it will require something more than limited observation, or ordinary ability, to answer its objections; my part, however, is merely the suggestion of a traveller, and I therefore conclude my paper by expressing a hope, that this important mineral may meet with more able investigation.

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* See the Note appended to the article of *Panna* mines, p. 106, of this volume.

VI.

ON THE

GEOLOGICAL AND MINERALOGICAL STRUCTURE

OF THE

Hills of Sítábaldí, Nagpur. and its immediate vicinity.

By the late H. W. VOYSEY, Esq.

Assistant Surgeon His Majesty's 67th Foot.

The hill of *Sítábaldí* although agreeing in form and interior structure with other basaltic hills in its neighbourhood, merits a more particular description on account of some peculiarities in the composition of the main rock, hitherto unnoticed by Geologists, and for the opportunities afforded by its extensive quarries of studying the varied structure of the rocks of the trap family, which is rarely to be seen in so distinct a manner.

The mass of the hill is composed of porous basalt, with a semi-columnar appearance, derived from numerous vertical fissures. It passes in some places, both in a gradual and abrupt manner into a coarse porous wacken or indurated clay, which in its turn changes in a similar manner to the nodular basalt or wacken, of which the northern and southern summits of the hill are composed. At the junction of these rocks, the passage is sometimes so gradual as to give the intermediate rock an indeterminate character partaking of the nature of both. At others, it is abrupt, yet notwithstanding the abruptness of the change, the vertical and horizontal fissures are prolonged into each and cross the line of junction. I shall not here enter into a greater detail of these appearances, but shall content myself with observing that the most satisfactory explanation of these phenomena, is derived from that theory which ascribes to the trap rocks an igneous origin, under pressure of a great body of water.

The semi-columnar basalt forming the greater part of the hill is very porous, containing numerous amygdaloidal cavities, which are for the most part merely lined with a peculiar mineral, which I presume to name [*]*conchoidal augite;* sometimes, however, they are nearly filled with it, or with calcedony, semi-opal, or carbonate of lime; the calcedony being usually covered with a coating of green earth. The rock itself is composed of hornblende and felspar, with the augite, so profusely disseminated, as to claim a right to be considered in some cases, as a constituent of the rock. This is, I believe, the first time that conchoidal augite has been found entering into the composition of basalt. The rock is fusible[†] and is of considerable specific gravity, notwithstanding its porosity. The vertical and horizontal fissures are not always straight, but are at times waved; they are also, sometimes lined with an infiltration of calcedony coated with clay and chlorite.

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[*] From the difficulty of procuring specimens sufficiently large to analyse, I have not been able to determine its composition exactly.

[†] I have lately had an opportunity of fusing a large piece of the *Sítábaldí* basalt in a steel furnace; the product after an hour's fusion was a fine black opake stone, resembling porous obsidian: glass bottles are commonly made in the Mediterranean from basalt, and that of *Sítábaldí* seems to be of an equally favourable nature for that purpose.

This rock is succeeded by an indurated clay or wacken, which at its junction with the basalt, frequently partakes of its semi-columnar structure, the vertical fissures being prolonged into the wacken, and the shistose structure of the latter extending into the basalt: these changes may be very favorably seen in the fosse, which surrounds the fortification.

The indurated clay or wacken seems to form but a small proportion of the hill, as it is not seen in the hollow between the greater and less elevation, the semi-columnar basalt being there uncovered by any rock. It also contains crystallized carbonate of lime and semi-opal, but calcedony coated with green earth, is the most common mineral found in it.

This rock passes into the nodular wacken, which, on a casual inspection, appears to be a collection of stones rounded by attrition, and involved in a matrix of clay ; when examined more carefully it is evident that this appearance is owing to a peculiar modification of the concretionary structure, developed by decomposition. Nuclei, of various sizes, are enveloped by concentric lamellæ, which peel off as decomposition destroys their cohesion. They are consequently seen in various states of decay and of sizes, varying from several feet in diameter to several inches. But their true nature is easily discovered by the mutual indentation of the different lamellæ, which surround their respective nuclei; the centres from which this pseudo crystallization has proceeded. The existence of the vertical and waved fissures, need scarcely be adduced as farther proof that they are not the product of alluvial detritûs.

It appears most probable that they owe their forms to molecular magnetic attraction, since they contain a very large proportion of oxide of iron (nearly twenty-five per cent.) as may be perceived by the great specific gravity of hand specimens.

The nodular wacken or basalt, is one of the most common forms of trap in the extensive districts, composed of the rocks of this family, south of the *Nermadá*.

It occurs perpetually in the extensive and lofty range of mountains, situated between the *Púrna* and *Taptí* rivers, and appears to form their principal mass. It is found equally abundant throughout the whole of *Berar*, part of the provinces of *Hyderabad*, *Beder*, and *Sholapur*, and appears to form the basis of the great western range of trap hills, which separate the *Konkan* from the interior of the *Dekhin*.

It is probably one of the main sources, when decomposed, of the black diluvial soil, to which *Hindsuthan* owes so much of its fertility. The valley or extended plain of *Berar*, that of *Hasanabad*, of *Seronj*, of *Nandiála*, south of the *Krishná*, of the *Pálnád*, bordering the *Krishná*, and numerous others, all lie near the course of rivers, which at some former period have covered these plains and formed their extensive deposits of alluvium. Whether the deposition originated in some sudden and partial inundation, or whether it was owing to the gradual subsidence of the waters of the great deluge, I think may be determined by cautious investigation.; I am at present inclined to think that the most probable cause was the latter.

The hill of *Sítabaldí* offers favorable opportunities, if the quarries are extended, of ascertaining positively whether the basalt is merely a superficial deposit, or is deeply connected with a mass beneath. It is surrounded on all sides by gneiss, or slaty granite, which is found at the base of the hill a few feet deep. Perhaps *Nagpur* affords more opportunities than any other part of India, of studying the geological history of these rocks, as it is situated near the junction of the primary and overlying

lying rocks. Numerous opportunities must arise during the excavation of wells and baths, of ascertaining the connexion of the strata beneath. A well in Mr. ALEX. GORDON's garden, near the base of the hill, of about forty feet depth, penetrates through three or four feet of black soil, succeeded by a magnesian siliceous clay, which appears to owe its origin to the decomposition of the gneiss, by which it is immediately followed, and which continues to the bottom of the well.

From the summit of the hill of *Sítabaldí*, the difference in the outline of the rocks eastward is very perceptible. * The flattened summits and long flat outline with the numerous gaps of the trap hills, are exchanged for the ridgy, peaked, sharp, outline of the primary rocks. At *Ramtek* and its vicinity, the rocks are of granite and gneiss. At *Dúngarí*, at *Palora* and *Parsúní*, are found crystallized marbles passing into gneiss, capable of receiving a fine polish. Some of them contain a small quantity of carbonate of magnesia. At *Khorarí*, a dolomite or magnesian marble is found also in gneiss. At *Nayakúnd*, *Parsúní*, and the bed of the *Pesh* river, granite and gneiss of various kinds, also quartz rock and sandstone; and foliated black manganese ore is in great quantity.

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* Captain BAYLEY's plates of the Battle of *Sítabaldí*, give a very correct idea of the flat outline of the basaltic trap hills at *Nagpur*.

VII.

OBSERVATIONS

ON THE

Geological Appearances and General Features of portions of the Malayan Peninsula, and of the Countries lying betwixt it and 18° North Latitude.

By CAPTAIN JAMES LOW,

Of the Madras Army.

It is with extreme diffidence that I venture on this subject, as it is one which cannot be fully elucidated without a much more extensive research than I have had it in my power to make, and a higher degree of geological knowledge than I possess.

Since, however, the countries alluded to, have not hitherto been geologically described, and as political circumstances preclude British research from a wide portion of these interesting regions, the Society will, I trust, receive with indulgence the results of my personal investigation,

The grand general features of the *Indo-Chinese* regions seem to be alternate ranges of hills stretching nearly north and south, and conforming occasionally to the general direction of Peninsular Tracts, and of valleys of various breadth, through which flow large rivers.

The principal ranges are, that which divides *Asam* from *Ava*, then the *Siamese* and *Ava* range, next the *Siamese* and *Cambyan*, and again the *Cambojan* and *Anam* range. The continuity of these appears to be most liable to interruptions as they approach the south, and none of them, as far as my information extends, can be compared in height to the secondary ranges of those lofty *Himalayan* mountains, from which they are evidently offsets. The broadest valley seems to be that of *Ava*, and the narrowest the *Cambojan* one. The general inclination to the south of the whole of the regions lying betwixt *Bengal*, and the sea of *Skamscatka*, is apparent from the course of the rivers being in that direction. From regions contiguous to the sources of these rivers, the tide of population which overspread the southern plains, appears to have flowed, a position which might be illustrated by the affinities of languages.

The *Indo-Chinese* ranges are in so far as we yet know covered by deep forests. It is only, therefore, in the ravines, formed by torrents, and on the face of an occasional precipice, that their structure can be conjectured; and these facilities are available at but a very few points, owing to the wildness of the countries in which they occur, and of the barbarous hordes which roam over them.

I will begin with that part of the *Malayan Peninsula* lying in about 4° S. latitude, and keeping on the west coast. This point is, in the *Perak* country, which is governed by an independent Malayan chief in alliance with the British. From this last circumstance we may hope in time to gain a more perfect acquaintance with its geological peculiarities.

Close to the entrance of the *Perak* river are the *Bountin Islands*, hilly, with rocky shores. *Granite* seems to be here the prevailing rock. The plains of *Perak* are chiefly alluvial, up to the line where a marked ascent towards the central range is discernible, and which may, perhaps, be averaged at fifteen miles from the sea. The range in question is a portion of the great N. and S. one, which divides the *Malayan Peninsula* longitudinally. The rivers to the eastward of it consequently disembogue themselves into the *Gulph of Siam*, while those to the westward enter the *Bay of Bengal* and the *Malacca Straits*. This range, generally, considered, lies nearer to the west than to the east coast of the *Peninsular*. Where it bounds *Perak* on the east, it is both lofty, and, in so far as observed, continuous. Gold has been found in the beds of some of the mountain torrents which join the *Perak* river. From specimens of ores of gold, found in the hills east of *Malacca*, it would seem that the matrix is most frequently quartz. That the *Malacca Peninsula* was the golden Chersonese of the ancients, cannot now be proved, but it yields at this day gold in sufficient abundance to render this position probable. The granite formation appears to predominate amongst the *Perak* hills, and in it are found the veins of tin from which the Dutch formerly derived much profit, and which now yields valuable supplies of that metal. The mines must be very rich, since even at this period the native workman seldom digs above ten or twelve feet below the surface, and often contents himself with merely washing the soil taken from the beds of rivulets, and separating the oxyd of the metal in the shape of a black sand. The oxyd of antimony is also obtained in large quantities amongst the hills, but my specimens being pure I cannot specify the rocks with which they are associated. Lime is also (according to native formation) obtained, but its nature and locality have not been ascertained. From some native accounts also it seems not improbable that coal will be discovered in this track. *Perak* is a fine country, watered by a river of a very picturesque nature, and it contains a considerable population of Chinese and Malays. From *Perak*, northward to *Penang*, the coast is level, with a few detached hills, not characterized by any peculiar feature which might contrast them with those we have been describing. *Penang*, it is well known, exhibits an almost exclusive granite formation. The granite is, for the most part, grey, and decomposable, generally flaking off by exposure. It protrudes at the summit of the hills, and may be found lining their base. Mica occurs occasionally in pretty large masses, and white quartz, regularly crystallized, is found sparingly. On the shores of several of the small islands lying off it on the south-east, conglomerate, tinged with oxyd of iron. is found as well as the usual granite.

That part of the great peninsular range in the latitude of *Penang*, is much broken; but many of the hills are of considerable height. The loftiest one, visible from *Penang*, may perhaps be stated at four thousand feet. They are almost all rich in ores of tin; and were European scientific men to be permitted to explore them, we might expect to derive interesting results from their labors. A table land of *considerable elevation* and covered with grass, is reported to be about north-east of *Penang*, in the centre of the great range. The jealousy shewn by the *Siamese*, has hitherto prevented me from visiting it. Marble is reported to be found in this direction; but no specimens have been obtained. The Malayan inhabitants are all friendly to the British.

That portion of the *Kedda Coast*, facing *Penang*, has evidently, in many parts, been rescued from the sea. The period when this happened is not traditionally known, although it is conjectured that it is not very remote: mounds of sea-shells are found about two miles inland. There are detached hills on this part of the coast, which contain tin.

The *Kedda Peak* (termed by the natives *Gúnong Cherai*), is an object of considerable geological, as well as geographical, interest. Its height has not been correctly ascertained. It may perhaps be stated at three thousand feet at least above the level of the sea, which washes part of its base.

The summit has not been reached, as far as I am aware, by any European, although perfectly practicable. This has been greatly owing to the jealousy of the *Siamese*. From specimens of rocks and ores brought from this hill by intelligent natives, who were sent by me to explore it, I am enabled to state with some measure of confidence, that it principally consists of the usual granite of this coast. On the sea face is a cliff washed by a waterfall, where large crystals of white quartz are got ;—similar crystals were brought to me from a spot near the peak. The summit is a granite rock, with a flat termination of a few square yards bare of vegetation, and accessible with difficulty. This mountain contains gold ; and tin ore was formerly obtained in large quantities on it. Various ores of iron were brought to me from it, and it is probable, that many other valuable minerals may yet be found there. This mountain abounds with all the valuable woods of this coast, amongst which are several kinds of fir. The inclination of the hill is apparently to the east, and there is a very remarkable break (of six or seven hundred feet, judging by the eye and telescope, at the distance of ten miles,) in the rock, east of the peak, which may have been caused by an earthquake.

The latter phenomenon, it may be remarked, is not followed by such violent effects on this coast, as on the *Island of Sumatra*, and on *Java*. The existence, however, of hot springs in various parts of the central range, indicates the prevalence of mineral substances, of which specimens have not yet been obtained.

Advancing northwards from *Gunong Cherai,* and passing the mouth of the *Kedda* river, which takes its rise in the central range and fertilizes an extensive track of rich soil, the first object which attracts the attention, is the elephant rock, a short distance north from *Kedda.* It is a dark mass of granite seemingly, and it shoots very abruptly out of the forests to the height, perhaps of four hundred feet.

The coast continues low to the northwards of this point. Turning to the *Laueang Islands,* we find granite still prevailing, but here in the " bird nest rocks," we are enabled to note the southern termination in this line of the limestone formation which has been traced by me up to the northern boundary of the *Martaban* province. I have no doubt, that detached lime rocks abound in the central range, but they are not connected with this formation in so far as we yet know. The first decided indication of the presence of lime, was observed in a perforated rock, lying off the N. E. side of *Pulo Trotto.*

The calcareous rock is here much tinged by oxyd of iron, and mixed up with different earthy substances. The strata are inclined to the west at an angle of about 30°

Several miles north of this point, the *Trang* rocks begin. The first of these was visited by me ; but it merits much narrower inspection, than time permitted me to make.

It is a huge mass of heterogenous rock rising out of the sea to the height of about three hundred feet. Its shape approaches to an oblong square, and it is rendered inaccessible by cliffs. The whole seems inclined at a slight angle to the south.

From the decomposing nature of the surface, it would be no easy task to arrive at a speedy conclusion respecting its whole structure. It appeared to me to rest on a granitic base, covered by various admixtures. The superincumbent mass is heterogenous. Lime stone in various stages; veins of quartz and ores of iron are most prominent; calcareous incrustations line the hollows of the cliffs; where also the agaric mineral abounds; —and the cliffs are, in some places, curiously marked by broad vertical ribbon-like streaks, varying in colour according to the strata from which the water, containing the colouring matter, has flowed—white, black, and dark bluish, and slate colours, are most frequent. At the south end about half way up the cliff, there are magnificent natural arches. The grotesque calcareous stalactites, which depend just over the entrances to these, give them, as a whole, the aspect of a decayed gothic ruin.

A cavern has been formed quite through the north end of the rock by the action of the sea below, and the gradual decay of the structure above. Stalactites here abound.

Our boat carried us into the centre of this cave; it is gloomy, but the roof is perhaps fifty feet high, and dome-shaped though rugged. Here were observed flimsy-ladders of flexible cane, stretched betwixt projections of the rock, and on emerging from the cavern, similar ladders were observed to have been arranged up the face of the cliff, in a zig-zag manner, here fastened to a jutting point of rock—there reeved through a perforated angle. These had been thus placed by adventurous Malays, in quest of the edible birds' nests. Their trade is more dangerous than that of the samphire gatherer, or the Hebridian Birder; but it is more profitable than either. Several of the birds' nest islands, in this line, have been so tortuously hollowed out by the slow operation of ages, that, previous to going in, the nester fastens to the entrance the end of the clew he takes with him, that he may not lose his way. On these occasions they use dammer torches. The eye of the swallow which builds these nests, must be peculiarly formed to enable it to work and nestle in such a labyrinth, where total darkness prevails.

A pocket compass was placed close to that part of the cliff, which seemed most strongly impregnated with iron ; but it was not affected.

Near, and to the north of this rock, is a very rocky island, termed *Ka Pesa* by the *Siamese,* because, in their legends, it is related, that an undutiful son having denied assistance to his parents, out of the profits of a successful voyage, the gods sent a storm which drove his vessel to sea, where it was transformed into this rock.

The general structure nearly corresponds with that of the rock just noticed ; but it has a most singular aspect from a series of peaks which rise from it—bleak and striated, and which, on a near approach, resemble the chimnies of glass manufactories. The geological features of this island may be best seen at the north end, where large masses have fallen from the cliffs. Here granular magnetic iron ore imbedded in a calcareous and micaceous gangue, was found in considerable quantitv. A nearly similar sort of iron ore abounds on the high ground on the main land, at the entrance of the *Trang* river.

These rocky islands are adorned by numerous beautifully flowering shrubs and trees, and are frequented by the white sea pigeon (Columbadelmaris), and by birds of passage. A coarse coral bottom prevails around each ; but the depth suddenly increases at the distance of two or three hundred feet from the shore : oysters are abundant. At the north side of the narrow entrance to *Trang* harbour, in N. Lat. 7° 20' is a remarkable calcareous rock, with several caverns in it. The carbonate of lime in conglomerated masses or in stalactites, is here much purer than that found amongst the islands just described. Several of the stalactitic masses are bell or fungus-shaped, the apex upwards, and when struck, are found to be remarkably sonerous. These are all tinged with iron.

Pulo Tilibon, which forms the northern side, exhibits granite and iron stone, with veins of quartz in it. From all that I have seen, it should seem that the lime formation becomes more compact and pure, as it is followed in a northern direction.

The rock in question contains a detached portion, having a stratified appearance, and inclining to the S. E. at an angle of about 35°. In one of its caves were observed twelve human skulls, laid out in a row. They were those, the Siamese said, of Burmans, who were slain in those wars, when they attacked and destroyed *Tilibon.* Part of the stockade, which surrounded the town, was yet standing, when I visited the spot in 1824, about fourteen years after its destruction. The thick planks, or beams, were quite sound, and very hard. The tree, from which these durable walls had been obtained, is the *Mai-ke-um* of the Siamese, and the *Rayú gittah* of the Malays.

The *Trang* river is broad—with a high ridge running at right angles to it, on the west side of the entrance. Granite rocks here protrude through the soil, which is red and ferruginous. The shore is overspread with lumps of micaceous iron glance very fusible. The iron is in small rounded particles—black, but yielding a reddish streak, and when reduced to powder, adhering to the magnet. The matrix is a brown ochre, which soils the fingers. The quartz, which is found imbedded in the granite of this coast, is generally very lammellar, and the plates transparent. There are several hills discernible from this place; but little information was obtained regarding the great range. The young Raja of *Ligor* informed me, that the pass, betwixt the hills, is difficult; but as he rode his elephant the whole way on several occasions, his account is no doubt exaggerated.

Most of the small islands, lying betwixt *Trang* and *Junk-ceylon*, seem, for the greatest part, composed of granite. It prevails in the latter island, and here again tin appears in proximity to, or interspersed in it, and its debris.

A range of hills, the highest of which, I believe, will not be found to exceed one thousand feet, stretches longitudinally through the island, with one large break in the middle. The island was probably once joined to the mainland, since the *Papra Strait*, which separates the two, is narrow and rocky.. The island, when I visited the interior in 1824, had a population of six thousand souls (Siamese.)

The tin formation seems to run in a continuous line from the southern extremity of the Peninsula up to about 15° N. Latitude. Beyond this point neither Burmans nor Siamese have discovered any mines. But as the countries, lying on both sides of the great belt of mountains, are, perhaps to a distance of twenty miles, respectively, from the skirts of the latter, inhabited by wild tribes of Karians, uninterested in the search for this metal only, it is probable that tin does exist in these latitudes. It shews itself again in *Thampè*, one of the provinces of the *Shán*, as the Burmans term the inhabitants, and lying, if I can depend on the distances given to me by natives of the country, in about 20° N. Lat. and Long. 99°-100. The natives call themselves *Plau*. They are shorter in stature than the Burmans, and their features partake much of those of the Chinese.

There the tin ore occurs in beds of streams mixed with sand. The natives do not dig mines to get at it, owing perhaps to its being of little value at such a distance from the coast. They have, however, by their own accounts, valuable lead ores, which they reach by deep shafts.

In Captain FORREST's time, when *Junk-ceylon* was visited by numerous native traders, the mines yielded an average annual quantity of five hundred tons of tin. But as the population has been reduced to about six thousand souls, and as the Siamese have mines closer to their capital, a very small supply only is now taken from the island. Perhaps it may be rated at one hundred Bahars of 446 lbs. averaged each. A Chinese smelter informed me, that he could afford to produce tin at a cost of one-half at the utmost of the market rate. The miners dig pits of from twelve to twenty feet deep; but seldom venture a lateral shaft. The ore is generally in round or oblong masses, with well defined crystals, and in a matrix of quartz, or bedded in masses resembling half decomposed granite, yet of considerable hardness.

The furnace in which the pounded ore is smelted, is made of a compact of clays and earths, is oblong in shape, and about three feet high. Alternate layers of ore and charcoal are put into it, and the usual horizontal *tube bellows* of the Chinese, is kept incessantly at work during four complete days (of twenty-four hours) and one night, when the furnace is cleansed. After some hours labor, the tin makes its appearance, and is run into moulds, and the furnace is fed with more ore and fuel.

The *Bay of Phúnga*, which stretches N. E. from *Junk-ceylon*, is remarkable for the magnificent rocks, with which it is studded. At the distance of ten miles, they appear like huge artificial pyramids; but on a nearer approach, their outlines change to columnar, or massive. The principal rocks occupy a line of about ten miles, in a north and south direction. The northern extremity lies behind the town and valley of *Phúnga*; the southern rests in the sea, about four miles from the mouth of the *Phúnga* river. Their direction, therefore, is nearly that of the *Trang* rocks. The part of the range, lying in the sea, consists of numerous detached rocks of different elevations, and mostly inaccessible. The height does not in any instance, I should state, exceed five hundred feet, and seldom falls short of two hundred. One of them has a very columnar aspect, which might lead a distant spectator to suppose it was basaltic. They are all, however, chiefly composed of, I suppose, primary limestone, and like the rocks which have been already described, exhibit no traces of organic remains. Some of the specimens of stalactite, which have been presented to the Society, were taken from one of a series of grottos in and near the base of one of the *Phúnga* rocks. These caverns are about six feet above high water mark. The roofs are low, and seldom exceed ten feet in height, and they look as if supported by the natural pillars of spar, which have been gradually formed by filtration from the top. Several of the stalactites have barely reached the floor—others touch the floor, and a double formation is going on. The sides of the grottos are lined with the same calcareous spar.

There is an insulated rock near this spot, which is perforated by a grand natural tunnel. To the top of the arch the height is about twenty feet, and grotesque-shaped stalactites depend from above the entrances from the roof. A boat can get within the arch.

The valley of *Phúnga* is about three miles long by one, on an average, in breadth, being oval-shaped, and widest near the sea. It is hemmed in, to east and west, by rocks and hills. Those on the west are least abrupt, and seem mostly granitic; those on the east have a very picturesque appearance, and where the river washes their base, present perpendicular cliffs of four and five hundred feet. They are even more purely calcareous than the rocks at sea, for many look at a short distance, as if formed of chalk. This they owe to the agaric mineral. Tin abounds in the granitic hills in the vicinity of this valley. The great hill range of the Peninsula, was not observed from this point, owing to the intervening rocks. But the Siamese chief informed me, that it must be *crossed* in the route thence to the opposite coast of the Peninsula. No information could be expected from him, as to the rocks associated there. The population here is about eight thousand souls, including six hundred Chinese, and about one hundred Siamese priests of all ages.

Passing to the northward of *Junk-ceylon*, the coast is bold for the distance of a degree; and lying about thirty miles off this line, are numerous calcareous perforated rocks, frequented by the edible birds' nest gatherers.

From all accounts obtained from native travellers—from personal observation when sailing up the coast, and with reference to the narrowness of this part of the Peninsula—it has appeared to me that the great central range is here of less width than at any other point. But I cannot admit, that this circumstance, as some have imagined, should give any color to the supposition that any internal navigation is, or could be, rendered practicable betwixt the *Bay of Bengal* and the *Gulph of Siam*. I have before me native plans, in which the hills are laid down as continuous. At any rate, the inclination of the countries towards the *Gulph of Siam* on the one side, and the *Bay of Bengal* on the other, is so great as to prevent the rivers which flow over them from being navigable to good sized boats, beyond perhaps ten or twelve miles from their mouths.

The sources of two rivers may indeed lie within a few miles of each other on opposite sides of a hill or a range—yet the spot where they respectively lose the name of mountain torrents, and become navigable, may be very widely asunder. It is true, that by running up the *Kra*, or any other stream in a boat, a traveller may get within two or three days march of the place of embarkation on a river on the opposite coast: and this is all that can, with our present information, be admitted. All the rivers on this coast are wide, and some are deep at their mouths; but, with the exception of the *Tenaserim* and *Tavoy* rivers, which incline to the northward and avoid the hills, they suddenly contract and grow shallow. Tin abounds betwixt *Junk-ceylon* and *Mergui*.

The coast of *Tenaserim*, from 10° to 12° 30′ N. is shut out from the ocean, by high and generally rocky islands.

Those which form the west side of *Forrest's Straits*, up to the N. point of *Domel*, in 11° 3′ N. (instead of 11° 21′ as he gave it), are well wooded, and are chiefly composed of granite. *Domel* is a fine island, twenty miles in length, by twelve, or thereabouts, in breadth, with a rocky coast. On sailing past a spot, described and sketched in FORREST's work, and at which he mentions having taken in marble ballast, I could only find a great quantity of large smooth boulders of quartz, which had been associated with slate; for, upon inspection of the coast, thick strata of soft, black slate, with veins of quartz, were discovered. The slate had, in some places, an admixture of iron ore.

In coasting *Domel*, the hills on the mainland are distinctly perceivable. The highest point was conjectured to be about three thousand feet high. These hills belong to the great range in all probability. The highest peak of *St. Matthew's Island*, may be nearly as high.

All the islands in this chain examined, shew bold coasts towards the sea.

There is a considerable opening north of *Domel*, where a distinct archipelago of bleak and rocky islands begins, and stretching north and south. The belt is formed of four or five parallel rows of islands, and may be twenty miles in breadth. They are not laid down in the Charts. A vessel, I sailed in, passed through amongst them in coasting, and as the numerous dangerous rocks with which this hitherto unexplored track abounds, rendered it necessary to anchor frequently, I had opportunities of visiting many of the islands. The channels are, for the most part, deep, and a vessel of two or three hundred tons can scarcely find anchorage near many of the islands when within half a cable's length of them.

Their formation is primitive. The granite is occasionally associated with black shistose strata, or sandy slate. The specimen produced, was taken from a vertical stratum, of exceedingly indurated shist tinged by oxyd of iron. Lime rock was not observed to prevail. But several of the islands seem heterogeneously composed. Occasionally quartz, white and tabular, was seen to pervade in broad veins the granitic rocks.

Several "birds' nest" rocks are scattered amongst this group, and it may be inferred that they are calcareous. Pearl oysters are occasionally picked up. The pearls got from them are seldom of much value. If pearl beds of any desirable extent do exist, the practice of diving for them, as at *Ceylon*, might be applied with advantage. The whole of the islands noticed, are destitute of any fixed population. But there is a tribe, termed *Chalome* and *Pasc*, the families of which rove about collecting the birds' nest, the dammer, the beche-de-mer, conch slugs, wax, scented woods, and other products of the islands. They live in covered boats, and appear inoffensive; readily bartering the above articles for such merchandize, as the *Burmans* bring to them.

The *Siamese* appear to exert very little, if any, control over these islands. Their part of the coast terminates at *Pak Chau*, a river of no consequence further than as it forms, according to *Siamese* opinion, the southern boundary of the *British* possessions in this quarter.

Leaving this coast for a space, I will now cross the Peninsula, and endeavour to give as brief an account of such geological and mineralogical notices as I have been able to obtain, respecting *Siam*.

The sea, which washes the shores of the Peninsula on the east side, is studded with numerous islands, bold, and, for the most part, rocky. The edible birds' nests being here procurable from the caves, it is probable, that lime abounds in the rocks. Along the shores of the *Chúmphan* and *Chanja* districts, ferruginous strata are prevalent, and loadstone is said to be procured from them.

At *Ban taphan nae*, nearly in the latitude of *Mergui*, are the only gold mines now worked in *Siam*. The gold is either in the shape of dust, or found in a reddish earthy matrix. To get this last kind of ore, pits of no great depth are dug. The ore is merely submitted to the agency of fire. It is not believed, that these mines yield annually more gold, than would be valued at perhaps about 15,000 rupees. But as the miners (about from two to three hundred, it is understood) only mine during three months in the year, and as they go very clumsily and unskilfully to work, the real value of these mines remains unknown.

A diligent author,* who visited *Siam*, observes of the *Siamese*, that " neither their mines of tin, nor those of copper, lead, and gold, have experienced the benefits of the industry and intelligence of the *Chinese*."

Previous to opening a mine, the *Siamese* propitiate the spirits of the ground and of the stream, by the sacrifice of cattle and poultry, and by offering up these and fruits on temporary altars. This custom is equally observed by *Chinese* and *Malayan* miners, on opening gold or tin mines. With respect to the *Siamese*, the practice is a direct breach of the primary ordinance of their faith " not to kill that which has life," and points to a period when they worshipped *Genii Loci*, and other imaginary *Dewtas*. Cornelians are found, it is said, on this coast.

Proceeding northward, till within about a days coasting of the *Siam* river, a hill, termed *K,hau Deng*, or " *the red hill*," appears on a point of land. The coast is covered with ferruginous earths and strata ; but of these no specimens have been obtained. Close to this place, and stretching for the distance of ten or twelve miles northward of it, is a very remarkable range of pyramidal hills and rocks, termed by the *Siamese* " *Sam sae yat*," or " the three hundred peaks." They vary in height from an hundred feet to perhaps twelve hundred feet ; some rise from the sea, others are scattered on the main land.

This account I give from native information, although European navigators have incidentally alluded to them. They take from hence a kind of *hone*, (perhaps an iron ore), varying in colour from black to white. The valley of *Siam* is chiefly alluvial, within the scope of the annual inundations of its river. The first rocky formation of any consequence northward of *Bankok*, the capital, is at *Prabát*, three days by water, north-east of the old capital, and where there is a famous impression of a foot of *Buddha*. The *Siamese* priests have long imposed this sculpture on their followers, who never doubt their assertion, that the legislator alluded to stamped the impression with his own foot.

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*Mr. CRAUFURD.

This *Prabát* has been made on the solid rock [a granite, if my information is correct], which protrudes at top, and a stair has been cut out of the rock to ascend by. A copper ore is said to be found on the flat grounds near this place. About fifteen or sixteen miles above *Prabát*, there is a low hill called *Phra Chauja*, where granite, from my information, prevails, and where the natives fancy they can trace on the face of a rock, the lineaments of *Buddha*. Iron ores are found here. At *Napphabúri*, on the south of the road to *Laos*, large quantities of a very white argillaceous earth are obtained, and red ores of sulphur are said to be brought from this quarter. At *Khorát* they use, it is said, a plum-pudding stone, or breccia, for building ; and at *Napphabúri*, in this quarter, they find yellow, red, and white ores of arsenic *(Realgar?)* a metal which enters largely into the *Siamese* Pharmacopœia. The range of hills, stretching N. E. from a point in about N. Lat. 16° on the east bank of the river of *Siam*, yields ore of iron in great abundance ; and the *Chinese* have, therefore, established a large party at *T,hasúng*, a town lying on a branch of the river. They manufacture various coarse articles of cutlery, which are rejected by the *Siamese* themselves, in favour of foreign importations of that metal. Iron mines exist also at *Sokkothai*, higher up the river. The range of hills dividing *Siam* from *South Laos*, is continuous, according to every account I have received from native travellers, who invariably go most of the journey by land. They affirm, that there is no water communication across the country; so, that the river *Anam*, laid down by some geographers,* appears to have no existence.

The *Me Nam*, or great river of *Siam*, has been traced by me, in native maps obtained from people of *Laos*, up to about 21° N. Lat. where are high hills abounding in hot springs. *P,hokhau Lo-ang Prabang*, a hill many days to the northward of *Laochág*, in the south of *Laos*, yields, it is said, gold and precious stones. It may be the *Mohany Leng* of Du Halde, where, he observes, were to be found "gold, silver, copper, tin, and red sulphur." At *Chantabún*, on the east coast of the *Gulph of Siam*, granite is believed to be the prevailing rock, and quartz-crystals, *Ceylon* diamond, and coarse rubies, cat's eyes, and other precious stones, are collected, it is reported, in the vicinity. Steatite is found in *Ligor*.

We now return to *Tenaserim*. The high islands fronting *Mergui* are, I think, of primitive granite; and *King's Island*, with most of the lesser islands in its neighbourhood, present bold granite cliffs to the sea.

The hill, on which the town stands, consists of granite, decomposed at the surface, with much quartz interspersed in veins. The ochery appearance of the soil, in some places, indicates the presence of iron, and tin ore is found in the streams at the base of the hill;—lead ore *is reported* to exist in the upper parts of this province. The rocks on the island forming the west side of the harbour, are strongly impregnated with oxyd of iron. In the vicinity of the town, argillaceous petrifactions are found. The clay contains some lime. But no marks are discernible near *Mergui* of lime rocks;—some petrified crabs were obtained. The province of *Mergui*, or *Tamau*, abounds with tin ore, especially to the *southward*.

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* Pinkerton and others.

The sea, northward to *Tavoy*, is pretty free of islands. Grey granite is the prevailing primitive rock throughout the province of *Tavoy*.

There is a low range of hills, which stretches north and south, close along shore, and shuts from the sea a great portion of the province; nearly opposite to the town of *Tavai*, on the west bank of the river at *Kamau*, is an elevated ridge of several miles in length, which is almost wholly composed of iron stone of different degrees of compactness. On the surface, the soil and gravel are reddish. But on a high part of the ridge, is a rock very hard and fine grained, but not striated, and of a blackish colour. It is strongly impregnated with iron, and so magnetic, that a piece newly detached and of a pound in weight, held a piece of iron, nine grains in weight, in suspension. It was with much difficulty, that a few specimens could be taken off with an iron crow. This rock might, from its black appearance, be supposed of meteoric origin. But it is evidently connected with the ferruginous strata beneath, and seems not to contain any nickel

Tavoy is a very hilly province. The first range connected with the great centre belt, lies about ten miles east from the town. Hence to the main range there is a succession of north and south ranges, gradually increasing in height, and having very narrow valleys betwixt them. Through these valleys flow rapid streams which, after pursuing the direction of the valleys to various distances, find outlets, and then turning westward flow through level tracks until they reach the sea. The route to the *Nay Dáng Pass* into *Siam*, lies about north-east from *Tavoy*. I performed the journey to the summit of the *Pass* in 1825, and on foot, as the road is impassable either to elephants or horses. Indeed the only paths, in some places, are the beds of mountain torrents. A dense jungle covers the face of the country, precluding the probability of satisfactorily pursuing geological pursuits. The tin mines, lying three miles off the route, were visited by me. They do not here deserve that title, as the *Tavoyers* merely wash the sand of the streams, and collect the fine black particles of ore. The temperature of the air is found to be about 64° or 65° until eight or nine o'clock, and that of the water 68° (FAHRENHEIT'S thermometer), so that the workmen never begin their labour until that hour. As the population does not extend beyond the first range of hills, and the mines are buried in the forest far beyond these, the men are exposed to the attacks of elephants and other wild beasts which here abound.

Other mines of tin lie on the southern coast below *Tavoy*, and a meagre, black, and slightly sparkling ore of antimony has been obtained from the province, but its locality I am not aware of.

Frequent vertical or inclining strata of hard slate, and sandy slate, are found at intervals to lie across the path; but wherever a bold cliff appears, scarcely any thing except granite is visible.

At *Laukyen*, fifteen miles north-east from *Tavoy*, (a halting place or circular cleared space of the forest), and lying a few hundred yards on the east of the route, my guides shewed me a hot spring in the almost dry bed of a torrent.

The adjacent strata were, after many hours labor, laid bare, and specimens were taken from the spot where the water bubbled up. The rock appears to be a transition slate, passing into limestone (for it effervesces slightly with an acid), and having thin films of pyrites betwixt the cubical portions which compose it. The water raised the thermometer to 144°. The gas which escaped was not inflammable. The pebbles around were incrusted with a calcareous salt. The water has no peculiar taste. There is a mound on the eastward of the spring ; but no volcanic indications were perceived in any direction.

The great *Tenaserim* river was crossed in this route in a track, where either perpendicular cliffs of granite, or wooded hills, hem it in on both sides. Its bed is strewed with large blocks of the same primitive rock. By leaping and stepping from one to the other of these, we crossed to the east bank. The breadth is here, as far as I can recollect, (in the absence of my notes) about thirty yards. It is quite impassable in the rainy season. From the appearance of the stream here, I should be inclined to fix its source somewhere about 15° 30′ north. The road, distance to the top of the *Nayé Dáng Pass*, is about sixty miles. In a direct line it is about fifty miles. It was found impossible to march early in the morning, owing to heavy dews and mist, and the whole day was often employed in getting over ten or twelve miles—so difficult was the march rendered by the necessity of crossing (often twenty times in a day) mountain torrents, and the streams they feed, and of ascending rugged beds of streams and ravines, where the guides were not unfrequently at fault. A considerable tract of table land was passed over during the route. The average temperature of FAHRENHEIT's thermometer *was at sun-rise 64°—and at mid-day 74° But it was often 72° at the former period, and 69° or 70° at the latter.

The rocks at the pass could not be well examined, owing to the thick jungle—but the surface is evidently a decomposing granite. From this elevation, which I am not inclined to rate higher than three thousand feet, four very distinct and higher ranges of hills were seen within the *Siamese* frontier on the east, while the lesser ranges on the *Tavoy* side could be easily traced.

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* The month was one of the dry ones.

From the view here obtained, I feel disposed to allow forty miles at the least for the breadth of the whole space, in this latitude, occupied by hills. The ranges are as nearly as may be parallel to each other

In my overland route to *Yé*, the surface was rarely found to exhibit any other than the granite formation—quartz was occasionally abundant.

At *En-bieu*, near *Kaling Aung*, on the left of the road, and in the middle of a circular level spot in the jungle, is a curious hot well. It was found to be quite marshy all around, although it was visited in the hottest period of the year. It was not without difficulty that it could be reached near enough for examination—both from the heat under foot and the treacherous nature of the soil.

The well is about forty feet in diameter. By throwing a bottle attached to a rope, allowing it to fill and grow heated, and pulling it suddenly back, the temperature was found to be 104° of FAHRENHEIT. But 4° more may be allowed for accidents. Not a rock or pebble could be seen near the well. A bleak on the surface, angular, sharp and disintegrated, scraggy granitic rock lies a short distance to the northward of it.

The water has not been examined by tests. From this hot fountain down to the stockaded town of *Yé*, in the small province of that name, the country falls rapidly (to the south.) A few detached hills are perceived at intervals, and on the east of the route a low granitic range stretches northward—resting on the south at *Tavoy Point*, and to the north in *Martaban Province*.

The low hill, on which the stockaded town of *Yé* stands, exhibits no peculiar features to attract a geologist—granite decomposed at the surface, is most prevalent, I believe.

On the route from *Yé* to *Martaban*, I perceived in the dry beds of rivers massive strata of striated clay slate of a fawn colour. These strata are either vertical, or dip at a considerable angle—*Martaban* and the adjoining countries, would well reward the labors of a geologist. As the *Burman* war was being carried on, when the former was visited by me, it was not without the imminent risk of being cut off, or of being made a prisoner by the enemy, then encamped on the north side of the river, that I was enabled to explore the country up to about north latitude 18° 20′.

A hasty geographical sketch of this province may not here be altogether irrelevant—for, without some idea of the localities of a country, the future geological traveller may find his plans prove abortive.

Martaban is bounded on the north, by a branch of the great central range of hills dividing it from *Siam*. On the south, it merges into the district of *Yé*, being divided from it by the *Balamein*, a narrow stream. On the east, the *Siamese* range presents a very formidable barrier, shewing at intervals peaks of considerable elevation. The highest of these was conjectured to be about five thousand feet in height. Across this wall, there is only one good pass, that termed *Pra-song-chú* by the *Burmans*, and *Phra Chedu-sam-ong* by the *Siamese*, "*the pass of the three Pagodas,*" and lying in latitude 15° 18′ 00″ N. longitude 98° 22′ 15″ E. according to Captain Grant's observation after the peace. Another, but difficult pass, lies directly north of *Martaban*. On the west, it is partly bounded by the sea, and partly by the provinces of *Chetáng* and *Thám Pagú*. It may be computed to contain about twelve thousand square miles.

The principal river is the *Krúng Mautama*, (of the *Peguers,)* or *Sanlún*, (of the *Burmans,)* which rises in a range of mountains to the north-west of *Che-ang Mai* in *Laos*—passes within two or three days' march of that capital—and after a turbulent course, apparently betwixt two of the inferior ranges of the great belt, disgorges itself with impetuosity on the plain just above the island of *Ka Kayet*, in about 18° 20′ north latitude. It is joined at the *Ka Kayet* stockade by the *Yúnzalen* river, which flows from the *Haphún* hills, lying in a north-west direction from hence; and which I believe to be the same, which I observed from the great *Shui Madú* temple at *Pegu*, to bear as follows—the northern extreme N. N.E.—southern extreme E.½ a part south—and about forty miles distant. But the stream was found by me to have a bar of granite across, about eight or ten miles beyond the stockade, and not to be navigable to the smallest canoes. Hence it rolls more quietly on till it disembogues itself into the sea at the *Khyet Khamí Pagoda*. Opposite to *Martaban*, it may be about a mile in width.

The other rivers which swell it are the *Dáng Damí Kyáng*, which joins it at *Mahi Phrá Pagoda;* the *Gyén Kyáng*, which falls into it at *Phrá Pyú*, or the "*White Pagoda;*" the *Attarám*, or *Attiyán* river, which enters it nearly opposite to the town of *Martaban*—the *Wakrú Kyáng*, which disembogues near the *Kyét Khamí Pagoda*—and the *Dáng Wein Kyáng*, which pours itself into the *Gulph of Martaban.* These are all navigable far inland by large boats.

The chief hills within the province are part of the *Tavai* range, with its branches—one of which is divided by the *Sanlún* river at *Malamein.* It runs in low broken hills, about fifty miles north of the town of *Martaban*, and joins the *Jeu Kyét* mountains—next a short range running across one of the upper branches of the *Attarám* (or *Attiyán*) river—the *Jeu*

Kyét Phra-táng, a high peaked hill, fifteen or twenty miles to the westward of the town—the *Jogabeu-táng* to the northward, and the two insulated hills, called *Dáng Dámi* and *Majin*.

The numerous detached and insulated rocky hills which are scattered over the plains, and the many islands which stud the expanded *Sanlún*, together with the dark and towering *Siamese* hills in the back ground, produce scenery of a very impressive kind.

The ranges of hills in this province betray granite as their chief ingredient. But the *detached* and very abrupt rocks and hills, of elevations of from two hundred feet to eight hundred feet, which shoot up from the plain, have in so far as examined by me, been found to be invariably composed of limestone. The limestone is in various stages, from an earthy and gritty kind up to hard marble—and the cliffs on several of them have the same marked features, which the *Trang* and *Phúnga* rocks display—being streaked with red, brown, and white, and evidently suffering a rapid decomposition. The plains on which these are based, are covered generally by an alluvial soil—but in some places, it is dark and porous, like the cotton ground of India. The sub-stratum in the lower parts is commonly a stiff clay, but towards the *Siamese* range the soil becomes more friable, tinged with oxyd of iron, or mixed with dèbris of rocks, and resting on gravel in large round masses. Here on the banks and on the low islands the *Khyén* tribes cultivate cotton, indigo, tobacco, and pulses. Potter's earth is obtained in abundance near *Martaban*. Of this, most of the utensils known by the name of *Pegu* jars, were formerly made.

On the low range of hills, on which *Martaban* stands, granite, perhaps, predominates. But at the town, many slaty and sandy strata having an inclination of about 30° here tinged with oxyd of iron, there intermixed with slightly calcareous and other matters, and quartz are observable. At *Malamein*, a *breccia* is found, which has been used in the construction of the Pagoda there. This substance hardens so much by exposure, that it will last for ages, as it has here done. On the high grounds, which occasionally flank the river, the surface is tinged red by iron ores.

About fifty miles by water up the *Attarám* river, and within about two miles of its eastern bank stands *Seinle-dáng*, one of the singular limestone rocks just alluded to. About mid-day, betwixt it and the river, and on a swampy plain, slightly inclined to the river, I was gratified by discovering a singular hot *fountain* (for it is of too peculiar a nature to be merely termed a spring.) The *Burmans* call it " *Ye-bú*," " hot water." The orifice is nearly a circle, the diameter of which is about thirty feet. The rim is of earth, and only raised about a foot above the surface of the water. Not having been prepared for such an interesting object, I had not provided myself with a line. But the depth is, no doubt, very considerable. The water was so clear, that the green calcareous rocks which project from the sides were quite distinct at a depth of twenty feet at least. A strong bubbling appears near the middle. A thermometer propended from a bamboo was dropped into the water, and after a space quickly withdrawn. An allowance of two degrees being made for loss of heat in the removal, the temperature by FAHRENHEIT's thermometer was found to be 136°, which is 12° hotter than the Bath waters.

Had any volcanic indications been observed in the vicinity, the circular formation of this well might have induced the belief that it had once been a crater. A visitor to this place ought to approach it with caution—since part of the water near the edge is covered with weeds, which so resemble the surface of the bank, that a person might unthinkly step on them to his inevitable destruction. He would faint instantly from the heat and sink. Although the wells on the plains were all nearly dry at the period when this fountain was visited,* yet it discharged twenty gallons on the least computation in a minute—and towards the east side. The leaves and branches which had fallen near were incrusted with a calcareous deposit—and the bottom of the rivulet was covered with a flaky calcareous substance. No specimen could be obtained of the rock, as it lies far below the surface. But from the greenish hue, perceived in it, we may suppose it to partake of the nature of the specimens brought from *Lankyen* hot spring in *Tavoy*. I drank some of the water, and was not afterwards sensible of any peculiar effect from it. Upon subsequently examining it with the obliging assistance of a Medical gentleman† at *Martaban*, it was found to be a chalybeate, and to contain lime in combination with some other earth or earths. The tests are enumerated below. This fountain lies on the route to *Siam*, and from many cocoanut trees scattered about, it is evident, that though now a jungle,‡ the plain once supported a numerous population. Near *Yé*, on the sea shore, there is a pond to which the *Burmans* ascribe marvellous virtues. It is said to grow quite red occasionally. Probably iron ores are abundant there.

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* I was favored on this occasion with the company of Lieutenant George, M. N. I., and Mr. Adams, of the Marine Service.

† Mr. Brown, A. S., M. N. I.

‡ 1st. Tincture of catechu precipitates a dark brown substance—hence the presence of iron is inferred.

2d. It does not blacken paper, dipped in a solution of lead.

3d. No precipitate is caused by dropping into the water a solution of nitrate of silver.

4th. When mixed with a solution of turmeric, (in equal proportions,) no sensible change of colour is induced.

5th. When mixed with an equal quantity of lime water, a light, while precipitate, is formed; which does not effervesce with muriatic acid.

6th. The concretion found on the leaves and common pebbles effervesces strongly with muriatic acid, indicating the presence of lime in the water.

Betwixt this place and *Malamein*, on the east bank of the same river, stands the very majestic lime rock *Phabaptaung*, the base of which is washed by the stream. It has been perforated quite through by a rivulet. The limestone composing it takes a fine polish—and large stalactites depend from the roof of the grand arch overhead. It, like the rest of the rocks examined, shews no traces of organic remains.

In rowing up the *Sanlún*, or main river, the first objects which attracted my attention were the *Krúkla-taung* rocks, being a continuation of the great lime formation. The river at one spot is hemmed in betwixt two rocks, and being thus narrowed rushes through with considerable impetuosity. The rock on the north-west bank overhangs its base, the latter being washed by the river. On a sharp, and one should suppose almost inaccessible pinnacle, a small Pagoda has been built, producing a pleasing effect to the eye of a distant observer.

The cliff I conjectured to be two hundred and fifty feet high. On that front facing the river, some niches have been cut in a pyramidal space, and in these stand many painted and gilt alabaster images of *Buddha*. A narrow opening leads into a magnificent cave, which has been dedicated to *Buddha*, since many large wooden and alabaster images of that deified mortal were found arranged in rows along the sides of it—the wooden images were mostly decayed, through age, and had tumbled on the floor. The rock consists of a grey and hard limestone. The cave bears no marks of having been a work of art. The *Burman* priests, who inhabit a village on the oppósite bank, could not afford me any information respecting it. No inscription was discovered on the rock. It is rather a singular circumstance, that no *Bali*, or other inscriptions on stone of any antiquity, have been discovered in the *Indo-Chinese* countries—and it is the more particularly so as regards *Burma*, where the natives have (with reference to their semi-barbarous state,) attained to a very respectable degree of proficiency in sculpture. The bells of their temples have generally inscribed on them some pious sentences, and the name and titles of the person who bestowed them.

The only inscription observed by me, was that which *Alongphra*, or *Alampra*, caused to be engraved on a marble slab; which stands under a shed at the great *Shui Madu* temple at *Pegu*. It records his valorous exploits and pious disposition. The alabaster, of which the *Burmans* form their images, is only procurable within the proper *Ava* territory. The *Prapatha*, or *Prabát*, is an engraving often found on granite slabs at temples—and is intended to represent an impression of a foot of *Buddha*. They contain many emblems, most of which are obscure, and only to be made out by the help of a *Phúngí*, or priest of *Buddha*. The *Martaban Phúngis* could not inform me when *Buddhism* was introduced into *Martaban*. But from several circumstances, it should seem, that the country was only settled about A. D. 1286. From an attentive examination of such *Bali* MSS., as have come into my possession, I am quite disposed to conclude, that the *Buddhist* religion reached the *Indo-Chinese* nations progressively from *Ceylon*—and that the *Bali* language, as now used amongst them, however varied the alphabets may be in which it is written, is identically the same with that employed by the *Cingalese* priests of *Ceylon*. This last approaches so very closely to the *Pracrit*, that it becomes doubtful which is the elder language of the two. A comparison betwixt them would shew, which is the direct derivative from the *Sanscrit*.

Above the rocks described, the river flows through a rich alluvial country, thinly inhabited by tribes of *Khyens*, or *Karians*. These people carry on a bartering trade with the traders of *Martaban*. They treated me with as much hospitality as their situation admitted of. They are generally a fine race of people—athletic, and of much fairer complexions than the *Peguers* and *Burmans*. Their whole deportment favorably contrasts with that of these two races

They live independently; keep dogs for the chase; cultivate cotton; weave it into cloth, and dye it with the indigo raised by themselves:—and they are very comfortably housed. They change their ground every two or three years. I met a whole tribe in rapid progress down the river. They gave as a reason that the *cholera* (which seems, from time immemorial, to have prevailed in the jungly parts of these regions), had swept off so many persons, that they had been obliged to abandon their village, and seek a new abode. Opposite the small *Khyen* village of *Michantaung*, which lies on an island, is a singular rocky hill; the base of which is washed by the river. It may be six hundred feet high, and it has a black and scorched appearance. It is almost bare of grass, and there are only a few trees on it. These grow in the hollows and crevices. It might be taken for basalt or granite at a short distance, but on a close inspection is found to consist of a black limestone, breaking off into cubical fragments. The ascent is abrupt and difficult, and the tread of the feet is succeeded by a hollow sound as if the hill was but one vast catacomb. Several pits, having circular orifices, and of about three feet in diameter, were observed in the ascent. They are of considerable depth, for stones thrown into them were heard for about twelve seconds, rebounding in their descent to the bottom. On looking down these, I noticed large fungus-shaped stalactitic masses hanging from the sides. Near the summit of the hill, the ridges of the rock are so angular and sharp that scarcely one of my people escaped being badly wounded in their feet.

From the top a most pleasing and extensive view was obtained of the surrounding country, and the bearings of remarkable objects were taken. On a bleak ridge, about two hundred yards from where we were, a wild sheep or goat was observed. This animal's colour is nearly black, and the hair shaggy. Several balls were fired at it without effect. The natives said, that this species was only occasionally to be met with ; but as *they* had never seen a sheep, it could not be ascertained from their accounts, whether the animal we saw was of the goat or sheep tribe. I may here observe generally, that the wild animals and birds found in the countries we have just been going over, are chiefly the following : elephants, which are very numerous ; the rhinoceros, which *Malays*, *Burmans*, and *Siamese* dread more than they do the elephant, owing to its savage temper ; the bison, which is found of a very large size in *Thedda*, the head being of a fawn colour ; the wild ox, of the size of a large buffalo ; and also a species, resembling in every respect the domestic ox ; the buffalo ; the royal tiger ; the leopard ; bears (but very rarely seen) , tiger-cats, about the size of a fox ; leopard-cats, having very beautiful coats, and being about the size of the common cat, but more slimly formed ; the fox-cat, with tiger stripes, and which is destructive to poultry—this animal lives in dens, but it climbs trees in search of prey.

The elk and various kinds of deer, are abundant. Baboons, asses, sloths, oppossums, flying and other squirrels, chameleons, and other varieties of the lizzard tribe, various species of the tortoise, alligators, and guanas, are very numerous. In *Tavoy*, the natives keep packs of large dogs, with which they run down deer. These dogs run by sight, and they are regularly kennelled. The breed seems peculiar. I observed a dog at a remote village in that province, equal in size to a Newfoundland dog.

Wolves, or wild dogs, (for I had no opportunity of judging which), are found in the forests. No jackals, or common foxes, have yet been discovered, and, it is believed, that they do not exist below the latitude of 19° north. Many kinds of tortoises, as before observed, and river turtle, were seen by me. The natives, especially the *Karians*, train dogs to search for them, as they form often a chief article of their food.

The birds are :—White sea eagles, white land eagles, hawks, of several species, vultures, and kites

The peafowl here exhibits a brilliancy of plumage, which far excels that of the *Indian* one. It is also a larger bird. There are, at the least, four elegant varieties of the pheasant tribe ; also, quails in abundance ; and several kinds of partridges, of which the green, with a red tuft, and the blue, are most conspicuous. There is, likewise, a jungle cock, having a rich blue and reddish plumage, and nearly twice the size of the common jungle fowl. He is well armed with two long spurs on each leg. Pelicans, and the usual tropical water-fowl, abound. A perfect species of duck, having a blackish back and whitish breast, and the weight of which is nearly double that of the common duck, is very common.

Leaving the *Míchan-táng*, and proceeding up the *Sanlún* river, the low rocks, observed on the banks, exhibit coarse black limestone. The high cliffs further removed, shew the more advanced stage of the lime formation. At *Ka Kayet* stockade, close to the hills, the granite again begins ; and here were found scattered about smooth quartz and other pebbles of several pounds in weight, which had been used after their ammunition had failed by the *Burman* garrison when defending themselves from the attacks of the *Siamese* ;—baskets, full of these pebbles, were arranged along the palisade inside. Several specimens of regularly chiystalized quartz were here picked up.

The "*Khyen Ni*," or "*Red Karians*," who inhabit the jungly and hilly tract, stretching from this place in a northerly direction, are of a very savage and warlike disposition. They use thick buffalo-hide for armour, and fight with spears and poisoned arrows. The climate of this province is temperate. At *Martaban*, during the rainy season, which is not the coldest, the following average was taken from a series of notes on the state of the thermometer :—

	Average of Fahr. Ther.	
	7 A. M.	4 P. M.
Fifteeen days in May,....................	78	82
Twenty-five days in June,..................	72	73
Forty-two days, from 1st July to 14th August,	77	80

The geology of Ava is little known, nor has any one of the many, who accompanied the troops up the *Irawadí*, favored the world with a connected sketch of the rocks observed on its banks. That the lime formation will be found to extend up to *Asam*, there is every reason to believe from the accounts received, and since it is known, that carbonate of lime in shape of the finest marble, and also alabaster, in a pure state, are very common in the country—thus countenancing the position taken up in another part of this paper, that the lime formation gradually becomes more compact and pure, as it bends to the north. Dr. HAMILTON observes, that " at *Prin* he saw part of the chain of hills which forms the northern boundary of *Pegu*, and that there sandstone and limestone were observed in flags. In *Thaumpe*, a *Shan* district, they have lead, iron, tin—some silver it is said, and limestone.

From all that has been here stated, it should seem, that granite forms the basis of all the continuous ranges of hills on the coasts I have described;—that a bold and marked lime formation runs parallel to these ranges, but that this is occasionally interrupted, as far as can be judged of from an examination merely of the surface—that schist is of very frequent occurrence, and that tin, in shape of an oxyd, and invariably associated with the granitic hills, or formed in their vicinity (and supposed to extend up to N. Lat. 20° if not beyond it) and iron, in various states of combination, are the *principal* metals throughout this wide range.

I have only now, in conclusion, to express a hope that this rapid and very imperfect geological outline may, at some future period, be filled up by a more able hand than mine.

VIII.

VIII.

DESCRIPTION

OF THE

NORTH WEST COAL DISTRICT,

Stretching along the River Damoda, from the neighbourhood of Jeria or Juriagerh, to below Sanampur, in the Pergunnah of Sheargerh, forming a line of about sixty-five miles.

By the late Mr. JONES,

Of Calcutta.

The face of this country is regularly undulated by short broken swells, resembling a chopping sea: the perpendicular height of many of the hills, which I have levelled, averages about sixty feet. The soil is not more than six feet deep, slightly calcareous, resting on grey sandstone that effervesces with acids, and in many places, where it is bare an efflorescence of soda may be scraped off. The sandstone is not more than seven feet thick on the table hills, but generally thicker and coarser grained in the valleys. The coal and coal metal bassets out in many places, but are delusive guides to the miner, as the greater part of them are the saddle strata that cover the hills like a cap, and seldom reach down to their bases: others again lie like shields or patches on the side of the hills, and extend a considerable depth below the bases. Beneath all these the proper coal beds will be found. The formation appears to me, from the result of many experiments, to be *wavy* and wheeling in a slight degree, carrying its line of *bearing* to an amazing extent with little variation; its breadth on the south-west side in the direction of *Bankora,* is not more than eleven or twelve miles from the river, further on in that direction the protruding rocks are sienite, hornblende, quartz, and masses of mica or talc, cemented with a small portion of sand. At *Bajkol,* seven miles above the confluence of the *Damoda* and *Baracan* rivers, the attendants on coal are lost, and the river is blocked up with gneiss, felspar, and granite. The coal district then turns off, crossing *Jeria* in the direction of *Bahar :* coal bassets appear a considerable way beyond. The attendants on coal also appear in the *Baracan* river, regularly downwards on the *Birbhúm* side, without any interruption, except a large whyndyke that appears seven miles above *Madgeah,* running in the direction of *Bishenpur*. The whole of the district affords rich and valuable iron ore of various kinds, but no limestone has yet been discovered, except the calcareous concretions that are found on the surface of the ground, and such as are in general use as a substitute for limestone all over *Bengal.*

Description of the works at Raniganj, with the different occurrences that took place during the sinking of the three shafts.

Previous to opening the works at the above place, I made small sinkings down to the clay slate or coal-metal in the valleys in every direction within three or four miles. I found them invariably dip E. by S. which threw the line of hearing to the back of the *Rajmahál* hills, considerably inland. There being little chance of finding coal long on the line of dip within reach, (and it soon bassets or crops out on the line of rise), I thought it proper to begin at this place, as I never saw the coal dip any other way, but with the regular strata that cover it. The *Rajmahal* hills are composed of mountain whin or basalt of an amazing thickness; at one place at *Motí Jharna*, a section or slip may be seen of sixty or seventy feet in height, and quite perpendicular: these hills rest on red-streaked ferruginous sandstone, of a very hard nature, such as is often the floor of coal, but I believe very seldom the roof—this circumstance favored my opinion, that the line of bearing crossed *Birbhúm* in that direction, and on the 1st December 1815, I began the first shaft. Having made my arrangements with the workmen, the sinking went on regularly but I was much astonished to find as I went down, that the strata gradually wheeled from E. by S. towards the N. W. and when the coal was found in shaft No. 1, it dipped N. W. which continued regular in every season and bed downwards, the dip of the upper strata forming a spinal line on the side of the shaft. The rainy monsoon having now commenced, and the workmen not attending regularly, I began sinking the shaft No. 3, and cutting platforms round both shafts to the level of high water in the river, with open adits to make the approach easy. When the coal was found in No: 3, it was within two inches of the same level as No. 1, and dipping due south, I thought this might be caused by a sudden wave or ridge in the strata, or I might be working on the edge of a very small basin—this created much perplexity. I again tried the country round with the former result, and was then in hopes, that I had got on the pivot or point where the strata wheeled, which would throw the line of bearing towards *Katwa*. To get more information, I opened the shaft No. 2, and although this was four hundred and eighty feet from No. 3, on the line of dip, coal was found in the same level, dipping N. N. W., which gives, in the three shafts, a difference of level of only two inches—and a line of dip and of bearing in each different, but the strata the same. Every appearance indicated lower beds of coal, than any yet cut through, and I continued sinking in shaft No. 1, in hopes of finding the low main, with some difficulty in keeping the water under, from not being able to keep the men at work by night on account of the bears and tigers, until I found the last stone bank suddenly change its declination from half an inch to the foot, to an angle of 45°. This great dip would make it appear a primary formation, although, I am inclined to think, it is merely, what is termed amongst miners, a trouble, occasioned by the wheeling of the strata; I, therefore, did not sink farther, as the coal is always fouled by these occurrences. I am now preparing to work the nine feet bed, from the six inch band, that covers the nine inch seam of coal, up to about six feet with an arched roof, leaving three feet of coal above the arch, the three inches of clay slate that intervene will prevent the water of the eight feet bed from dripping down, and the feeders, of the seam or bed in work, will descend below the springing of the arch, and leave the roof tolerably dry. When the mine has been worked in this manner to a certain extent, the nine inch seam and three feet bed, can be readily wrought, leaving the six inches and two inches bands on the floor, as waste or dead; but if the mine is continued in work for any length of time, it would be prudent to carry the waste up, and leave the floor clean. The coal of all these three beds, is of an excellent quality; its cleanliness renders it peculiarly adapted for culinary purposes;—it resembles the *Sunderland* coal in every respect, but leaves more cinders and ashes.

An account of the Strata met with in sinking the Colliery at Rániganj, December, 1815.

	ft.	in.
Yellowish clay, mixed, in some places, with soft black concrete pebbles, ...	6	1

Grey

	ft.	in.
Grey sandstone, slightly calcareous,	5	0
Yellow soft clay slate,	3	0
Clay slate, rather sandy, with a mixture of mineral charcoal,	1	0
Very hard, bluish, streaked, and gritty slate	7	0
Tesselated band of grey basalt, dipping to the S. E. two inches to the foot,	1	2
Coarse grained, very hard and gritty slate, bluish grey colour,	3	6
Very hard stone band, grey tessalated basalt, dipping S. E. one inch to the foot,	1	10
Very hard, bluish, streaked slate, as before,	7	0
Blackish clay slate, with faint impressions of vegetables, and small bits of pure coal in many parts,	6	8
Black clay slate, without impressions of vegetables,	2	9
Black soft muddy clay,	0	4
Coal No. 1, slaty and dirty,	1	3
Clay slate,	0	2
Coal No. 2, better than No. 1,	0	4
Coal metal, or hard shale,	0	2
Coal No. 3, pretty good,	1	3
Coal metal, or hard black shale,	0	7
Coal No. 4, pretty good,	8	0
Coal metal, or shale,	0	3
Coal No. 5, very good,	9	0
Argillaceous stone band with impressions of flowers,	0	6
Coal No. 6, better than any of the above,	0	9
Argillaceous stone, with impressions of flowers,	0	2
Coal No. 7, better than the last,	3	0
Black hard shale,	2	1
Sandstone band,	0	5

Hard

	ft.	in.
Hard black shale, with impressions of vegetables, ...	1	3
Coal No. 8, bad, and full of gold coloured pyrites, ...	1	1
Tessalated claystone, with impressions of vegetables, ...	2	4
Grey sandstone band, ...	0	2
Shale, with impressions of vegetables, ...	0	5
Grey sandstone band, ...	0	4
Shale, with impressions of vegetables, ...	0	3
Grey sandstone, ...	2	0
Conglomerate bank of sandstone, clay slate, and other matter mixed in a confuse and mottled manner, ...	3	7
Bank of hard, sharp, gritty, greystone, with cutters, and the dip declining more than in any of the top strata, ...	3	6
Total, feet	88	2

Retrospect of occurrences, and opinions formed thereon, while searching for Coal in Bengal.

The N. W. coal district exhibits a considerable degree of confusion, increasing as you proceed upwards, and is admirably adapted for the use of an indolent race of people, as coal, sufficiently good for common purposes, is within the reach of every body. Knowing that dislocation of strata, always occasions the coal to be foul and dirty, I opened the works in a situation where I expected to be most free from it, but the plan of the works will shew, that I was not quite successful, although I have ascertained a most valuable point ; viz. the wheeling of the strata in the most desirable direction that could be wished, crossing the great line of navigation somewhere about *Katwa,* where I have not the least reason to doubt, that coal will be found, and the advantages that will result, must be abundant. Taking into consideration the various occurrences in the N. W. and N. E. quarters of *Bengal*, I am induced to think that the coal formation of both countries joins under the delta of *Bengal*, and that the alluvial deposit is of no great thickness; the dip of all the coal seams on the N. E. frontier, favors this opinion, and it is not improbable that this great line of coal enters *China*. From the *Garrow* hills into *Cachar*, I am satisfied of its continuation, as I discovered coal and its attendants the whole way, and found a piece of coal imbedded in a slate rock in *Cachar*. The best informed people of *Manipur*, assured me of their having traced it into the *Burma* country, but they do not use it in *Manipur* for any purpose ; it is called by them, " *amúbalang*." I am inclined to think, this coal district marks the easiest and best road into *China*. The *Surma* river is navigable for small boats into *Manipur* but the people on this frontier are averse to travellers proceeding into their country, and when they have power, resist it.

One of the principal advantages which I anticipate from the introduction of a cheap and plentiful supply of coals into *Calcutta*, is the being able to burn lime with it, at a moderate expense. At *Sylhet*, the whole of the lime is burned with wood—an article that has of late become both scarce and dear, so that they are now obliged to depend on a foreign country, *Cachar*, for their fuel ; and for which, large. sums are annually sent out of our country. But in the event of the limestone being brought to *Calcutta*, and then burned with coal—that article could be had fresh and much superior to the lime as now brought, which has been burnt at least, perhaps, a year before. Besides the saving in quality, from the freshness of the lime—the deterioration sustained by the lime getting wet in crossing the great rivers, and the boats taking in salt-water in the *Sunderbans*, will be obviated, and the expense of carriage would be less, from the boats requiring no roof, and from the insurance being less—the goods being of little value, and subject to no detriment from being wet.

The *Shergerh* district abounds in iron ores; and I find that immense quantities can be procured there at very little expense, and from the experiment I have made, I have no doubt, but extensive forges might be wrought in that district advantageously. Of other ores—there is lead in the neighbourhood of *Lakshmipur*, in the *Bhagalpur* zillah, and I have reason to suppose, copper may be found in *Dholbhúm*, near *Rajwáha*, in a stream called *Guru Nadi*, that empties itself into the *Subanrekha*.

IX.

EXAMINATION AND ANALYSIS

OF SOME

SPECIMENS OF IRON ORE,

FROM BURDWAN.

By H. PIDDINGTON, Esq.

In the following Analysis of Iron Ores from Burdwan, much care has been taken to ascertain correctly the presence and quantity of Phosphate of Iron and Manganese,* which two substances principally affect the qualities of the Iron when smelted; the process was conducted in the humid way, and the separation of the Manganese was obtained by Mr. Faraday's method—digestion of the Oxides in a solution of muriate of Ammonia with sugar.

No. 1.

BETWEEN JAMDE AND SUKHRAJ.

Sp. Gr. 3143.

Blowpipe—acquires a metallic tarnish and a shaggy, porous appearance, becomes magnetic: with borax or charcoal, fuses into a dark and dirty green glass. The blue laminæ burn with the scintillation peculiar to iron, become porous, and have a metallic tarnish; they appear to be a deut-oxide of iron.

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* Oxide of Manganese.

When calcined, the pulverised ore, which is of a yellow brown, changes to a deep chocolate red; probably from the privation of the carbonic acid.

CONSTITUENTS.

Water and Carbonic Acid,	8	50	
Silex,	4	00	
Alumine,	4	75	
Carbonate of Lime,	5	15	
Deut-oxide of Iron,	76	00	—55 Iron.
Oxide Manganese,	1	55	
	99	95	

NOTE.

This specimen probably contains from 58 to 60 per Cent. of Iron, for the portion analysed was found, by digestion in nitric acid, to acquire 8 per Cent. in weight, probably from the peroxidation of the blue laminæ.

No. 2.

NO LABEL WITH THIS SPECIMEN.

Sp. Gr. 3081

Blowpipe—becomes magnetic with a metallic tarnish, fuses with borax into a clear bottle-green glass.

CONSTITUENTS.

Water,	5	75	
Silex,	3	20	
Alumine,	0	40	
Lime, with a trace Mag.	1	00	
Oxide Manganese,	4	00	
Peroxide Iron,	85	30	—5950 Iron.
	99	65	

NOTE.

I refer this specimen to scaly red Iron Ore, or Iron Froth of Jameson, Vol. III. p. 208.

No. 3.

NO LABEL WITH THIS SPECIMEN.

Sp. Gr. 3400

Blowpipe—becomes magnetic, and fuses with borax into a very dark and somewhat dirty green glass.

CONSTITUENTS.

Water,	6	25	
Silex,	8	50	
Alumine,	0	50	
Lime Phosphate Iron,	Traces.		
Oxide Manganese,	0	0	
Peroxide Iron,	84	50	—59 Iron.
	99	50	

NOTE.

Ochry-red Iron Ore, or red Ochre of Jameson, Vol. III. p. 210. (?)

No. 4.

MAL CHAITI.

Sp. Gr. 3141.

Blowpipe—becomes magnetic, and acquires the metallic tarnish: with borax on charcoal, fuses into a pitchy slag.

CONSTITUENTS.

Water,	6	0	
Silex,	4	50	
Alumine,	1	75	
Carbonate of Lime,	3	35	
Oxide of Manganese (red)	16	00*	
Peroxide of Iron,	68	00	—47 5 Iron.
	99	60	

NOTE.

The large proportion of Manganese in this specimen is remarkable, but the process used for obtaining it leaves no doubt as to its identity, for the solution of muriate of Ammonia will not dissolve oxide of Iron. It may be found useful to mix with other ores, which may thus afford better Steel than they otherwise would. See Jameson, Vol. III. p. 232.

No. 5.

PAOLTA KANOWA.

Sp. Gr. 3587.

Blowpipe—Scintillates, becomes magnetic, and acquires the metallic lustre; with borax on charcoal, fuses with slight ebullition into a very opaque green glass.

CONSTITUENTS.

Water,	7	0	
Silex,	7	90	
Alumine,	0	60	
Lime,	0	00	
Phosphate,	Trace.		
Manganese,	10	25	
Peroxide Iron,	74	00	—51 5 Iron.
	99	75	

No. 6.

NO LABEL WITH THIS SPECIMEN.

Sp. Gr. 2857.

Blowpipe—becomes magnetic, and externally of a metallic lustre; with borax on charcoal, a dark enamel.

The pulverised ore, like No. 1, is of a pale yellow brown, changing to a deep chocolate red in calcination.

CONSTITUENTS.

Water and Carbonic Acid,	9	50	
Silex,	27	50	
Alumine,	1	50	
Oxide Manganese,	9	00	
Deut-oxide Iron,	51	00	—37 Iron.
	98	50	

NOTE.

Like No. 1, this specimen acquires weight (about 8½ per Cent.) by digestion in N. Acid: it is certainly too poor an ore to be smelted, unless under very favourable circumstances, but trials might be made of its effect on the qualities of iron produced from mixtures of it with other ores; there seems to be ground for supposing that Silica sometimes combines with Iron in the metallic state.

No. 7.

DESER GERH.

Sp. Gr. 3645.

Blowpipe—becomes magnetic, and assumes the metallic tarnish; with borax on charcoal, a dark coloured enamel studded with bright gold spots, resembling avanturine: the fragments translucent and of a bright golden green.

CONSTITUENTS.

Water, ...	6	0	
Silex, ...	3	75	
Lime, ...	0	50	
Alumine, ...	0	50	
Phosphate Iron, ...	0	90	
Oxide Manganese, ...	1	50	
Peroxide Iron, ...	86	00	—60 Iron.
	99	15	

NOTE.

The very beautiful appearance produced by the blowpipe, may probably be owing to the conversion of Phosphate of Iron into Phosphuret of Iron, by the combustion of the charcoal support.

The process used in the foregoing analysis differs from those indicated by the books; I have therefore subjoined a memorandum of it for the satisfaction of the scientific chemist.

1.—Weigh the pulverised ore at the temperature of the atmosphere, and calcine at a low red heat, the loss indicates the water, and if there is change of colour (from yellow to deep red brown) probably of carbonic acid.

2.—For 100 grains of the ore take 1½ oz. muriatic acid, boil it gently over a lamp in a covered vessel for twenty minutes, add four ounces of water, and boil again for a few minutes; this dissolves every thing except the silica, alumina,* phosphuret of iron (if any exists), sulphate and phosphate of lime: filter and wash the residuum perfectly, and calcine it: its weight is that of the silica and alumina—it may be tested for phosphate and sulphate of lime, if necessary.

3.—To separate the alumina, boil on the residuum sulphuric acid, diluted with thrice its weight of water, this will dissolve the whole of it, and leave the silex untouched.

4.—Evaporate the muriatic solution at a gentle heat; when nearly dry, pour upon it about half a pint of well boiled distilled water, transfer the whole to a jar or flask, and keep it closely stopped for twenty-four hours: if any precipitate forms, it is phosphate of iron, which may be separated as usual.

5.—Drop sulphuric acid into the solution, the lime, if any, will precipitate as a sulphate; separate it and calcine at a low red heat, and by the scale of equivalents, the quantity of carbonate of lime may be known.

6.—Precipitate the solution by one of caustic soda; filter, wash, calcine, and weigh the residuum, which consists of the mingled oxides of iron and manganese.

7—Digest these in nitric acid, with a gentle heat, allow it to remain exposed to the air till nearly dry, calcine again at a red heat, stirring it often, and weigh it; if any increase of weight has taken place, oxygen has been absorbed, and this must be allowed for in the results.

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* None could be detected in repeated trials.

8.—To separate the oxides of manganese and iron, boil them in a solution of muriate of ammonia, with a little sugar, the whole of the manganese will be dissolved, and the iron left, (it has been ascertained by independent experiment, that no oxide of iron is taken up, and prussiate of potass will satisfy the chemist that it is manganese): precipitate the manganese by water of ammonia cautiously added, and filter; if the liquid has any colour, a portion of the oxide has been re-dissolved by the excess of ammonia, and will precipitate on allowing it to evaporate; when the liquor is perfectly limpid, the whole has been obtained, and may be collected as usual:—This is Mr. Faraday's process for their separation.

X

NOTICE OF THE OCCURRENCE OF GYPSUM IN THE INDO-GANGETIC TRACT OF MOUNTAINS.

By Capt. J. D. HERBERT, Sup. Min. Sur.

In the Wernerian arrangement of rocks, we find distinct places assigned to the titles of *Primitive*, *Transition*, and *Flœtz*, Gypsum, leading to the conclusion that this mineral is found, to some extent, in rocks of these several ages. Some geologists, however, appear to doubt the existence of Primitive or Primary Gypsum. Dr. Macculloch, in his "classification of rocks," hesitates to admit it. So does a writer in the 20th volume of the British Review, who yet adopts the Wernerian arrangement, as, in the main, conformable to observation. Professor Jameson states, that it has not been found in extensive masses in any primary rock. Professor Cleaveland admits its occurrence in the Alps, but it is most probable that he alludes to the fact mentioned by M. Humboldt in his "Gissement des Rochers," who states that at the Splugen pass, in the Alps, primitive gypsum occurs mixed with dolomite, in beds subordinate to mica slate. With regard to Transition Gypsum, its occurrence is less questionable; but all authorities concur in fixing the principal and most important deposit of gypsum, to the newer red or saliferous sand-stone, (the red marle of England, and bunter sand-stein of Werner) or in its associated rock, the mountain lime-stone.

2. It was with these considerations in my view that I have always looked to the hills which bound on the south side, the several *dúns* or vallies that stretch along the foot of the great mountain tract, as the most probable locality in which to find this substance. They answer perfectly in character to the description given of the red marle of England. That they are really a type of the saliferous sand-stone, is proved by the occurrence of extensive deposits of rock salt in their prolongation towards the Indus.

3. The gypsum, however, of which I have the honor to submit specimens, is not found in those mountains, but in the clay-slate formation which bounds these vallies to the north, and which certainly possesses none of the characters of a secondary rock. It will be differently named by the followers of different systems; those who admit a transition class, will probably distinguish it by that term; while those who reject that class will, at once, call it primary: it possesses the characters of the transition clay-slate in its granular composition, in being associated with a fetid lime-stone, and in lying between the secondary and the better-defined primary strata. It is to be noted, however, that the gypsum occurs in very small quantity; it appears to me, indeed, certain, that whatever be the age of the including rock, the gypsum itself is of comparatively modern formation, and similar in its origin to those masses of stalagmitic lime-stone which are found in every rock, from the oldest gneiss to the

newest flœtz rocks, and that it is a merely local occurrence. This opinion I derive from the very limited quantity in which it is found, from its being associated with a sulphuretted lime-stone, and lastly, from its containing fragments of the neighbouring rock.

4. The principal deposit occurs in the bed of a stream which leaves the hills immediately below the village of *Nágal*, in the *Dehra Dún*— This stream, so well known to visitors who come here from the *Haridwar* fair, as deriving its name from a spot called *Sansar Dhárá,*[*] or the dripping rock. This is a perpendicular bank of fifty feet in height, which, for a breadth of sixty or seventy feet, is faced with pendent stalactites, from which, and from the brow of the hill, descends a continual shower of drops The water contains carbonate of lime in solution, (probably through the medium of carbonic acid) and is continually depositing it, so as to add to the number as well as size of the stalactites.

5. Two miles beyond this spot, at the confluence of another stream which comes from the left, the water of which is also charged with carbonate of lime, is seen the gypsum associated with a rock of rather an anomalous character. It has all the aspect of a lime-stone, but refuses to effervesce with acids, or at least does so very feebly It is frequently of a deep black color and fetid odor, particularly when struck or fractured. The odor is that of sulphuretted hydrogen. As it passes into well characterised lime-stone, it must be considered, geologically, as one of the numerous types of that rock, though, as it is so highly charged with argillaceous, and probably siliceous matter, its claim to the title of a lime-stone would not be so obvious in a hard specimen, it is one of an

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[*] Or, according to some authorities, *Sastar Dhárá.*

extensive series of beds included in clay-slate which, as I have before observed, may be either transition or primary, according to the observer's views. Fragments of the clay-slate, as well as of the lime-stone, occur in the gypsum; the former rock is distinctly stratified, and dips east with an inclination varying from 30° to 50°; the lime-stone is not so generally stratified, or at least the stratification is often very obscure.

6. The gypsum is of the prismatoidal species of Professor Moh's, of the variety called foliated granular; it is of a snow-white color, the lustre is equal, or perhaps a little superior to that of white marble—It is scarcely translucent, or if so, only in a low degree. One small specimen which I saw was perfectly so, and had all the appearance of the most beautiful alabaster. The specific gravity I find to be 2.24, which is within the limits determined by Professor Moh; the hardness is about 2.0. In strictness, however, the hardness of a mineral cannot be determined from specimens in which the individuals are so small, at least not in the determinate manner required in the scientific system.

7. A second deposit had been discovered, about two miles up the bed of a stream which falls in opposite to *Sansar Dhárá*, by a gentleman who had visited the spot, and mentioned the occurrence to me. I was not successful, however, in my attempts to find it, although I met with a sufficient number of fragments to indicate the neighbourhood of some larger mass. The description given, with an examination of the specimens, enable me to decide that it was a small bed, or mass, in clay-slate. Some of the specimens had the slate adhering; it appeared evidently to have been formed by infiltration, or deposition from water, subsequently to the clay-slate, as the bed which, in its greatest extent, was nearly horizontal, had taken a downward direction, so as to fill up a perpendicular crevice in the slate. The gypsum exactly resembled that of the preceding locality.

Though I could not find the principal bed, I detected a small mass of an irregular figure, enclosed in angular debris, which, from its impurity and the freshness of its surface, had been, I conclude, formed in that situation. The water of this stream is impregnated with sulphuretted hydrogen.

8. The third locality is on the ascent from the village of *Rájpúr*, immediately below the hamlet of *Jarí Páni*, situated in the range which rises to the north of the *Dún*. It has been found, as yet, only in veins, in a blue lime-stone, and chiefly of that variety called fibrous. Here, too, as at both the other localities, the rocks develope, on being fractured, a strong odor of sulphuretted hydrogen. How far this fact may be connected with the origin of the mineral in these places, remains to be determined.

9. The strong family resemblance which the lime-stone rocks bore in this place, to those in contact with the gypsum, at the former two localities, was sufficient warrant of the actual existence of the mineral, in greater quantity, in the immediate neighbourhood. And I was afterwards fortunate enough to discover it not many miles from the spot where these fragments had been picked up. This fourth locality is on the northern face of the range, in the ascent from the hamlet of *Ranon* to the summit. It is found in some quantity, and of the same character, and under precisely the same relations, as at *Sansar Dhárá*. The masses of which there are several, are all superficial, and contain fragments of the black fetid rock on which they lie, which also, like that at *Sansar Dhárá* though non-effervescent itself, passes into one that is—and which also, when rubbed or struck, gives out the odor of sulphuretted hydrogen.

10. In the first volume of the new series of the Geological Transactions, a specimen of gypsum, as also of anhydrite, * is enumerated as amongst those presented to the Society by MR. COLEBROOKE, in the name of Captain, then Lieut. GERARD. I have also heard of a specimen in a Calcutta collection, which had been presented by Dr. GOVAN. I am not aware of the locality of the latter; the former was found somewhere in the bed of the *Spíti* river, on the confines of *Ladák*, and at no great distance from a primary formation. No particulars are, however, given of the mode of its occurrence These are the only instances of gypsum being found in these mountains, that I know of, besides those detailed in the present paper. Who was the first discoverer of the Dehra gypsum, I cannot say. I have been told that the substance had been familiar to the residents in the *Dún*, who confounded it with white marble, and that Captain GRANT, of *Sahárunpur*, was the first to suggest its real nature.

11. Gypsum is used as a material for statues, vases, columns, and similar works of art. The purer and more crystalline varieties, are even used for ornaments. When the water which it contains, and which amounts to twenty-two per cent. is driven off by burning, it forms the plaister of Paris, or material for stucco work, and for casts. It is also used (unburned) as a dressing for land, extensively, I believe, in America. The quality of the mountain gypsum is such as to fit it for all these purposes, except the second; but the quantity which has, as yet, been discovered, is not, perhaps, sufficient to render it an object of much attention. A careful search might be successful in laying open greater stores,

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* I have in my possession a rolled piece of Anhydrite, presented to me by G. W. TRAILL, Esq. Commissioner; but I have mislaid the particulars of his note: it was, however, from the neighbourhood of the Snowy Peaks.

though, from what I have premised, there is little hope of finding any very extensive beds in the immediate vicinity of the present quarry.

List of Specimens forwarded by Dawk Banghy.

No. 1.—Is a specimen from the quarry, and will serve to give an idea of the best picked quality. (Art. 5.)

Nos. 2 and 3.—Are specimens of fragments from the bed of the stream. (Art. 7.)

Nos. 4 and 5.—Are specimens of the mass found in angular debris. (Art. 7.)

No. 6.—Contains imbedded fragments of associated rocks.

POSTSCRIPT.

Since first drawing up this paper, I have had access to one by M. BROCHANT, on the gypsum of the Alps, which it appears, till he undertook the examination of it, was considered to be a member of the primary class of formations. M. BROCHANT finds this opinion untenable; and from a large induction, he thinks himself entitled to conclude, that all the masses of gypsum in the Alps which he has examined, (and which he particularly remarks are superficial,) with whatever rocks associated, belong to one æra—an æra later than that of the newest of the rocks it accompanies. Now, in one of the lime-stones of this association, he has detected organic remains; so that if his conclusion of the cotemporaneous formation of these apparently unconnected masses be sound, they become, at once, referable to an æra posterior to that of primary formations. This so far confirms my view of the origin of Himalaya gypsum.

I ought to add, that, in mineralogical character, as far as that can be fixed by description, the gypsum of the Alps bears the closest resemblance to that of the Himalaya. Add to this, that they are, in both cases, found in superficial masses, which can hardly be called either beds or veins, that they are apparently independent and limited in extent.

XI

ON THE

MINERAL PRODUCTIONS

OF THAT PART OF THE

HIMALAYA MOUNTAINS,

LYING BETWEEN THE SATLAJ AND THE KÁLI (GÁGRA) RIVERS;

Considered in an economical point of view: including an Account of the Mines, and methods of working them, with suggestions for their Improvement.

By CAPTAIN J. D. HERBERT, 9th Regt. B. N. I.

Late Sup. Min. Survey, and Assist. to the Sur. Genl. of India.

The survey of the mountains, of which I have had the superintendence, having been brought to a close, by order of Government, I have, in the selection and arrangement of my materials for the formation of a final Report, thought that the accompanying paper on the mineral productions of that tract might be acceptable to the Society. It forms a communication intelligible in itself, and independent of the other details; while it is not of a length to fatigue the attention. A subject as yet untouched by any pen, it may be not even without its interest.

The metallic ores are the principal productions considered in an economical point of view, and the details relating to them, including an account of the mines and the method of working them, constitute the larger portion of the paper. I have added such suggestions as have occurred to me, for the improvement of the more obviously defective processes. But possessing little (if any) knowledge of practical mining, it is very possible that my suggestions may not be always improvements. The reader will take them for so much as they are worth, and no more.

As the subject is a popular one, I shall not affect any precision or refinement of method, but endeavour to communicate the little I know in the most intelligible form I can; guided only by convenience as to the order in which I shall notice the different substances. They may be divided, then, into two sections—the first to consist of those which do not furnish metal, the latter, including all the metallic ores.

I.

Of minerals, not useful to the metallurgist, though otherwise productive, the following are found:

1. Sulphur.
2. Green Sulphate of Iron.
3. Alum.
4. Bitumen.
5. Graphite.
6. Gypsum.
7. Limestone, and
8. Potstone, or Indurated Talc.

I shall bestow a few words on each of these, and then proceed to the second section, comprising the Metallic Minerals.

1.—*Sulphur.*

1.—*Sulphur.*

This substance appears to deserve the first notice, if it be only for its value as an ingredient in the manufacture of gun-powder. During the late war, its price rose to £30 per ton in Europe, and it would seem a subject not unworthy of attention, to ascertain in what quantity and at what price we could draw it from our own provinces. There are several sources of supply within these mountains; but it is to be feared that the expence of carriage would neutralise any profit to be expected from the more remotely situated of these. It is found in the deposits of hot springs, occurring in the bed of the *Rámgangá*, and of the *Garjia* rivers; in the province of *Kamáun*, mixed with carbonate of lime, from which it is readily separable by a subliming heat.—It occurs in considerable quantity in some of the galleries of the lead mines at *Mywár*, on the *Tóns*, in *Jaunsár*.—It may also be obtained in the first roasting of copper pyrites, as is practised at the PARYS' works in Anglesea, or of the ores of Galena, as was effected in the lead mines of Cronebane, in Ireland. It is not easy, without further enquiry, to estimate correctly the amount derivable from these several sources. Doubtless it would be considerable, and probably greater than any demand likely to arise immediately.

2.—*Green Sulphate of Iron.*

In connection with the deposites of sulphur and carbonate of lime occurring at the hot springs, there are also found extensive surfaces covered with an efflorescence of green sulphate of iron. This substance might be further obtained, in any quantity, from the iron pyrites of the mines. The conversion of the sulphuret into the sulphate is effected by reducing it to small pieces, exposing it to the air, and occasionally sprinkling it with water; operations requiring little labor, and involving no other expence.

3.—*Alum.*

3.—*Alum.*

Alum has not (as far as I know,) been yet found in Europe, otherwise than associated with the argillaceous schists. In America, however, a notice lately appeared, to which some degree of interest seemed to attach, of its having been found in micaceous schist. Our mountains afford another example of this fact. Near *Almórah*, in the bed of the *Cosilla*, it may be seen as an extensive efflorescence on mica slate, and it is probable that, by quarrying and lixiviating the rock, profitable quantities of the mineral might be obtained. From observations made when I was occupied in other duties, and not so precise as to the exact nature of the mineral, I think it probable that there are many similar examples of its occurrence, and that it is by no means rare in our mountains.

4.—*Bitumen.*

Bitumen occurs, but in no great quantity, if we may judge from the price it bears. It exudes from the crevices of a lime-stone rock, on the summit of the range between the *Sarjú* and the *Rámgangá*. On exposure to the air it hardens. It is used by the natives as a medicine.

5.—*Graphite.*

This substance has been found in round nodules of sizes, from one to three inches in diameter, scattered on the summit of a ridge composed of a highly carburetted micaceous schist. No bed, or mass in *situ* has been yet observed; but there is little doubt of the existence of such from considering the character of the rock, combined with the mode of occurrence of the mineral. Many of the nodules are more or less contaminated with quartz and mica, while, in one specimen, there were portions of quartz that had much the appearance of veins.

Almost all the nodules have more or less of the metallic lustre on the outside, owing to the degree of friction they have undergone. But the fracture surface is always dull; the composition being, apparently, fine earthy. On being rubbed or cut, it recovers its polish. That the absence of lustre on the fracture is dependent on its state of aggregation or composition, as mineralogists call it, seems further probable from its extreme porousness. One specimen, by some trials, appeared to absorb one-fourth of its bulk of water.

The specific gravity of those specimens apparently most free from foreign contamination, varied from 2·21 to 2·26. There is little doubt that, in the case of a mineral like graphite, the specific gravity is a valid test of its purity. It is interesting, then, to compare these values with that generally assigned by the best authorities. Amongst the older writers, there is such a range of results as warrant their rejection altogether. Professor MOHS, one of our best modern authorities, assigns 1·8 to 2·1 as the limits—HAUY 2·089, as an actual determination. SCHRADER again, who undertook a particular examination of the graphites from different countries, states the specific gravity of English specimens, remarkably pure, and one of them from Borrodale, at 2·32 to 2·46. However this may be, the mountain graphite is, certainly, of inferior quality—although I have succeeded in manufacturing a very tolerable pencil from it, and even in cutting out a small cylinder, such as is used in the patent pencil cases. It is also to be noted, that the graphite in England undergoes the preparatory operation of being boiled in oil. It is possible that such a process may considerably improve the quality of the mineral.

The uses of graphite are not confined to the construction of pencils, and there is a demand for very inferior qualities of the article. Adverting to the increasing employment of steam engines, it may be safely said that a sufficient quantity of even the quality yet found, would not be without its value. It is well known to be the very best anti-attrition application for metallic surfaces, when mixed with tallow, or other greasy substances. A mixture of this kind is useful, too, as a preservative from rust for articles of cast iron, and it is equally found to improve their appearance.

6.—*Gypsum.*

Of the more bulky articles, Gypsum, of the discovery and geological relations of which an account is given in another part of this volume, is doubtless the most valuable. Its pure white color and granular composition, fit it for works of ornament. It is, however, probable, that its chief use in this country, for some time, would be as convertible into Plaster of Paris, and affording a material for cornices and ornamental work, to the banishment of the very rude productions of this kind we have hitherto put up with. There is, perhaps, sufficient quantity of it to answer any demand, likely immediately to arise. When the Government House was last repaired, it was considered desirable to obtain a sufficiency for the purpose above indicated ; but the fact of its occurrence within our mountain provinces was not known at that time. As it is within fifty or sixty miles of water-carriage, it might be expected to pay for its transport.

7.—*Limestone.*

Marble is the rock next in value. Although it is not found of very brilliant colours, yet it is not deficient in beauty, and might, I think, be found to defray the expences of working It is indubitably superior to the very coarse marbles of the western provinces. A white dolomite, of a fine grain, approaching to compact, is found in many places. A variety, exactly answering to the description of the Iona marble, occurs at no great distance from the plains, and would certainly be admired. Another, at no great distance, is a flesh-colored dolomite, with purple clouded delineations, which, to judge from hand specimens that have been worked and polished, promises well. All the preceding are fine grained, almost compact. A marble of a more crystalline grain is found on the road to *Bhadreenath*, above the *Bishen Ganga*. This is a large mass; but, perhaps, too far from the plains to be of any value. Rolled pieces of crystalline limestone are found in many of the torrents within the zone of greatest elevation, proving that beds of this rock are, or were to be found within that tract.

8.—*Potstone, (Indurated Talc.)*

This rock may be substituted for many of the purposes of the former. It admits of considerable, though not equal polish, and in its great sectility, and the consequent facility of shaping it, there is an advantage. It may be cut with a knife, and by means of chisels, rasps, and files, may have any delicacy of ornament impressed on it. It may be turned in the lathe, and in this way are formed in Europe vessels, which are used for preparing food, having the advantage of standing the most intense heat: as a material for small furnaces and crucibles, it is valuable on this account. In ornamental work, its inferiority of polish and peculiar oily lustre, prevent its emulating marble—yet it is not without its beauty and its correlative gem—the chrysolite, which has something of the same peculiarity of appearance, is highly valued. So well are the uses of this stone understood in Europe, that at *Chiavenna* in *Italy*, it is said, a very considerable trade is carried on in articles manufactured from it, amounting to fortv thousand piastres yearly. In *Ireland*, where, as in these mountains, it has been found in a primary formation, containing also copper, it forms a profitable article to the proprietors of the mines.

Serpentine, a mineral nearly allied to potstone, has not yet been found, except as an ingredient in other rocks. On the other side of the *Káli* river, (the boundary of the British authority,) it is found in sufficient quantity. The natives apply it to the same uses as we do, i. e. ornaments and small utensils of various descriptions. I have seen a very beautiful specimen—the handle of a small knife in a *Khúkerí*, sent as a present. I have myself two large specimens of a very good quality, obtained through the kind assistance of Mr. TRAILL, the Civil Commissioner.

9.—*Granite.*

By a certain latitude of expression, granite, though not exactly a mineral, may be ranked under the head of mineral productions. There is a very beautiful porphyritic grey granite close to the cantonment of *Almorah*, which would furnish fine ornamental pillars, or slabs of any size, and to any extent. Under this head also may be noticed, a variety of toadstone which has been found in fragments, and the original mass of which is doubtless to be detected. It has a greenish grey basis, with white crystals interspersed, and when polished, has rather a beautiful appearance.

10.—*Borax.*

Borax, though not occurring within the British tract, yet as forming a valuable article of commerce, should not be omitted. The whole supply of the European market passes through these mountains. It is found in a lake, which would appear from some accounts, to have the power of reproducing it It is sold at the *Bagéswar* Fair, (twenty-three miles from *Almorah,)* in two states, picked and unpicked. The first consists entirely of crystals, varying in length from one, to one-eighth of an inch. These crystals are very flat hexagonal prisms, with trihedral summits. They are of an oil green color, and nearly, if not quite, opaque. In the other state, it contains a good-deal of Borax-dust, which consists either of very minute crystals, or of fragments, broken off the larger crystals, of the sand or earth, forming the substratum of the lake. from which it is procured, and (not unfrequently) of impurities, with which it is fraudulently adulterated. The picked Borax (or larger crystals,) is, itself, very far from being pure, and the method of purifying it, is said in England, to be a secret confined to a few—I could perceive no difficulty, beyond the length of time required for the deposition of the peculiar matter by which it is contaminated. I have found Borax of one solution, perfectly equal to the purposes of the arts. When pure, it is quite transparent, and nearly colorless. It is an article of such great utility, (for its actual uses are limited by the high price it bears) that it appears desirable the purification might be performed on the spot instead of transporting it to such a distance in its impure state, thereby enhancing the price. Indeed, owing to the high duty, which amounts to a prohibition, the price of Borax, in the *Calcutta* market, whether raw or purified, is the same, viz. fourteen to seventeen rupees a maund. At *Bagéswar* it is five rupees.

The preceding details are sufficiently meagre, but this must necessarily be the case as none of the substances found in our own provinces, have yet been sought for as articles of commerce: so that, except the mere fact of their occurrence, there is little to communicate. In the following Section, which includes an account of the mines worked, I shall be more full; though I fear there may still remain many deficiencies, and many particulars of interest to be supplied.

II.—METALLIC PRODUCTIONS.

The metallic productions of the mountain provinces, though hitherto inconsiderable, as far at least as regards the quantity of metal raised, might, it is probable, under judicious management, become profitable enough to repay any attention bestowed upon them. No mine of the precious metals has yet, it is true, been found within the limits of the British authority, although the discovery of such beyond the frontiers is said to be far from rare. There are, however, circumstances which seem to indicate the existence of gold within the limits of the British tract. Several of the mountain rivers which have their sources within this tract are known to furnish gold; and, though the produce at any particular spot be scanty, yet when we consider the whole extent of surface from which the metal is obtainable, the quantity is far from inconsiderable. At all events, the fact furnishes proof of the actual occurrence of gold in some part of the strata which these rivers traverse. In the case of the *Rámgangá*, the supply is traced to a tributary stream, called the *Béni Gangá*, which has its rise in the lower mountains, as it is only below the confluence of the two that the sands are found productive. In that of the *Sona Nadi*, it is still more limited, as that stream has a very short course wholly within the *Patlí Dún*. And with regard to the *Alakanandá*, I may mention that I have a specimen of granite, I obtained at *Kédarnáth*, one of the sources of that river, in which occurs a speck of native gold. Considering, indeed, all the circumstances of the case, it is, I think, far from improbable, that gold will yet be found in its native matrix within our mountains.*

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* Such a discovery is, however, more likely to be the effect of accident at some distant period, when the progress of population and improvement together shall have left scarcely a spot unexplored. That a systematic search holds out few hopes will be evident from considering the history of gold mines all over the world. How fruitless the most prudently conducted examination of a tract positively known to contain gold, and in some quantity, may turn out, is to be seen in the detail of the proceedings adopted in Ireland, to trace the gold found in diluvial gravel in the County Wicklow, to its parent source. The reason of this, as well as of the inferior productiveness *in general*

Of copper, lead, and iron, the metals next in value, there is no deficiency; or I should rather say, there ought not to be any; for the actual produce in any of these metals, is trifling in quantity, and inferior in quality. There are many considerations which combine to prove that the mountain tract, extending from the *Setlej* to the *Brahmapútra*, is rich in copper. With regard to iron, it may be said to constitute a considerable part of the country; either as a constituent of rocks, in the form of ironstone, or in the numerous and extensive beds of the better defined ores. Lead also is found in abundance; and is worked as well as the two preceding in many places, and with considerable profit. With regard to the other metals, little is known. Antimony is found, combined with lead and sulphur; but the ore is not worked. Manganese has been detected as entering, in small quantity, into the composition of one of the iron ores. Perhaps, were its characters and value known to the miners, it might be discovered. Arsenic, in the state of sulphuret, is imported from beyond the frontier; but I have not heard that it has been found within our provinces. Of the rarer and less extensively useful metals, it is impossible to pronounce with certainty. There is, of course, a probability, that some of them which may be said to be geologically connected with the existing formations, will be found. Nor does their non-occurrence hitherto, militate against that probability; when it is considered, that their properties and value are alike unknown amongst those with whom the task of discovery has hitherto rested.

The metals which yield revenue; are COPPER, LEAD, and IRON. The GOLD obtained from the sand of rivers; paid during the *Gorkhalí* rule, a small

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of mines of the precious metals, may be found in their comparatively small produce, thereby occasioning an expence in searching for or raising them, which, in most cases, more than balances their superiority of value. It is the accidental discovery where no expence has been incurred, or the falling on a rich vein in a mine already worked which constitutes the prizes in this lottery. For one who makes his fortune, hundreds lose.

small duty; but the amount was too trifling to render its continuance expedient, and it was accordingly abolished by the Commissioner. I think, however, the amount of metal obtained from this source, might be increased by attempting the operation on a larger scale. Hitherto the work of an unassisted individual; who has neither means or inclination to do more, than will earn his daily pittance; and who compelled to execute every part of the process himself, necessarily loses time, and does nothing well; it is not to be wondered that the produce has been trifling. Mercury is used for the final separation of the gold; but it is driven off again in an open vessel, and consequently lost. On the small scale on which they work, this is not felt to be a loss. The common account is, that a man's daily labor will earn him two annas: but this estimate is certainly much under the truth.

The method followed is abundantly obvious. The gravel in which the gold-dust is always found; and which in some rivers is the superficial deposit, in others, lies under a bed of sand; is collected in heaps, and washed on a stage, or imperfect riddle, made of bamboos. The pebbles of any size are retained by this, and then rejected; while the sand which passes through the interstices, is carefully preserved. When a sufficient quantity is collected, it is put into a wooden trough, of about three, to five, feet in length, and a foot broad: being filled with water, the whole is agitated by the hand, and such a degree of inclination skilfully given, as shall carry off all the lighter particles; leaving a heavy black sand, behind. It is in this sand, that the particles of gold are found. It is triturated with quicksilver, which takes up the gold; and the amalgam being separated from the still.remaining impurities, is set over a fire to evaporate the mercury: the gold remaining behind, in the vessel.

Of the mines, at present, worked in these mountains; those which yield COPPER, are undoubtedly the most important. With regard to the

IRON mines, although they do not hold out an equal prospect of immediate advantage; yet there is little doubt, but that the revenue derivable from them also, might be much augmented; and, with very little modification of the present processes. Eventually, they may be found the most valuable of all; but this must be the result of a state of things, not in existence at present. The LEAD mines are next in importance; and judging from their former value, (which was greater than the total amount of all the mines of whatever metal at the present day;) they would seem to be, even not much less worthy of attention.

1.—*The Copper Mines.*

There are seven copper mines; or I should say, seven places where copper ores are extracted; for at some of them, the mines or excavations, are very numerous. These seven localities, with the rent they pay, are as follows:

Dhanpúr,[*]	1200 Rupees per annum.
Dhóbri,	
Gangóli,	1000
Síra,	
Pókrí,	600
Khari,	40
Shór Gurang,	50

None of these are very advantageously situated, considering the expence of carriage in the mountains. But as buffaloes[†] may be extensively employed on good roads; and the breed appears to thrive in these provinces; it seems easy to obviate any objection, arising from the present difficulties of transport.

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[*] The localities of these mines, and of the other minerals, will be indicated in the Geological Map, which I hope soon to lay before the Society.

[†] An average Buffaloe will carry two maunds, with great ease, up the steepest ascents.

Of the probable value of these mines, it is difficult to form any thing like a correct idea; owing to the miserably contracted scale on which they have been, hitherto, worked. The chief thing of course to be considered is, the productiveness of the several veins or beds of ore; for supposing the quality of the metal sufficiently improved, there is little fear of a market being wanting.* It is not, however, easy, to obtain precise information on this subject: for the mines themselves are inaccessible to a European; or indeed to any, but people who, from their childhood, are accustomed to penetrate them. They resemble, as Mr. TRAILL has observed; rather the burrow of an animal, than the path of a human being. For this reason, it is impossible to speak, from actual observation, as to the productiveness of any particular repository of ore; and all we can do is, to form probable guesses. In *Chili*, it would appear, that the average produce of about 500 mines, is six tons each annually. From considering the rent of our *Kemáun* mines; and the price of copper (two rupees a seer;) allowing also, that the produce is double the rent; we shall have only one ton, for the amount yielded by the *Dhanpúr* mine: and half a ton each, for those of *Gangóli*, *Síra*, and *Pókri* The others, are too small to be worth considering. Supposing then that these four mines, have naturally an equal average of ore, with those of *South America;* we see that there is great room for improvement, and a fair prospect of advantage. On the average of six tons for each of these four mines; *Kemáun* would yield twenty-four twenty-four tons annually, instead of two and half as at present: and the revenue ought to encrease in the same proportion; that is, from 2700, to 27000 annually. But this is not all. There is little doubt of the existence of the ore in many other places: and were an improved system to be introduced, and the value of the metal consequently to rise in the market; a stimulus to investigation would be given, which might reasonably be expected to lead to the discovery of other sources of the ore, at present unknown.*

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* It appears by Captain Hall's work on South America, that notwithstanding the quantity of Copper thrown into the market by the Hon'ble Company; the greater part of the produce of the mines of Chili, (3000 tons annually) finds its way to the Calcutta market.

The principal mine, in point of value, *Dhanpúr*, owes its rank in the scale, not only to the great value of the ore yielded; but also to the nature of the rock in which it is situated. This rock, a red dolomite, is of such consistence, as to require seldom, if ever, any props for the support of the roof; and scarcely any additional expence, after the gallery or chamber is once excavated. Whereas, in the others, the rock is often so tender as to require timbers for its support; and even so supported, it fails every year in the rainy season; when a new expence is to be again incurred, without the prospect of any immediate advantage. This, is more particularly the case, with the *Pókri* mines. In the *Dhanpúr* mine, the work once effected, there is no occasion to repeat it; and every foot of excavation made good, is a permanent acquisition. An equally important advantage is, the continuance of the working season all the year round.

The compact structure of the rock, or perhaps the great elevation of the mine, and its proximity to the summit of the mountain; gives it another superiority which is no inconsiderable one: a freedom from water, and consequently, from the expence and trouble of drainage. One of the effects of this advantage is, that the miners have been enabled to follow the deposit of the ore, in all its ramifications and changes of direction: and the interior of this mine, presents quite a different appearance from that of others; being a succession of chambers, situated at various levels, and in various directions.

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* I am told that the mine at *Pókri*, called the *Ráj Khán*, yielded one year 50,000 Rupees: and at *Dhanpúr*, it is known that in consequence of an earthquake which shook the mine and laid open new veins of ore; the profits of the lessee were, that year, very considerable. Every one who travels in the mountains, must be struck with the numerous indications which present themselves of the existence of this metal. While writing this paper, a new vein of ore has been discovered, and leave asked to work it.

The ore is of that kind called GREY COPPER; (the *Fahlerz* of the Germans.) Many species, chemically speaking, perfectly distinct, have been confounded under this name. Four at least are certain—one of which contains iron as well as copper; two, iron and arsenic, but in different proportions; and the fourth, iron and antimony. They are all sulphurets, and the yield of copper is from thirty to fifty per cent; that is of the pure mineral: for no working ore, can ever be expected to give that proportion. The *Dhanpúr* ore, is the most valuable of the four: and contains fifty per cent. of copper; besides iron, and sulphur. It is always amorphous, either massive or disseminated. GREEN CARBONATE is sometimes found, but in no quantity.

The *Pókri* mine, or mines, are situated in a talcose schist: which on one side, passes into a talcose gneiss; and on the other, into a chloritic schist. All these rocks are so soft, and even rotten; as to have rendered vain every precaution of the miner: and the galleries excavated, have been constantly subject to accidents. When I visited the place; they had all fallen in: and, there was no lessee. I was unable, therefore, to procure proper specimens: and can only judge from the imperfect indications observed, in examining the rubbish of the mine. These seemed to point to, VITREOUS, and, PURPLE COPPER; the two most valuable of the sulphurets: the former, yielding eighty per cent. metal. The waters from this mine were observed to be impregnated with SULPHATE of COPPER.

The *Síra*, and *Gangóli* mines, are situated in beds of indurated talc, or potstone; which are again, enclosed in dolomite. Occasionally the former, occasionally the latter rock, forms the roof, and sides, of the mine. The dolomite, has a large crystaline grain; and great tenacity; and forms a perfectly durable work, when excavated. It is not so, however, with the other: at least, not always. When massive, it is, I believe, to be depended on: and it has then, a great recommendation in its extreme sectility; and the ease with which it is worked. But it occurs, sometimes, of such inferior consistence; having much the appearance of re-united debris; as to require support: and to occasion much inconvenience, and even, danger.

The ore, at each of these places, is COPPER PYRITES. I have never seen any crystallised specimens. It is accompanied by IRON PYRITES: which is occasionally found in the pentagonal dodecahedron; but most commonly, in such irregular and anomalous forms, as are with difficulty, describable.* I have observed specimens also of GREY COPPER: but in small quantity. The working ore is, no doubt, copper pyrites; and the quantity of copper it contains, may be taken at thirty-five per cent. This is, of course, to be understood, as before remarked, of the pure mineral: uncontaminated by the matrix.

The KHARI, and SHÓR GURANG mines, are similarly situated—the ore produced, is in so small a quantity, as not to require any lengthened notice. I have observed GREY COPPER, COPPER PYRITES, and CARBONATE OF COPPER: chiefly, if not always, disseminated. An important advantage, which all the mountain ores, I have yet seen, possess; is a freedom from any mixture or combination of arsenic: a metal which, above all others, deteriorates the quality of the copper; and is most difficult to remove.

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* Possibly composite forms.

The method of working these mines, is, with the exception of that at *Dhanpúr*, (which has already been described) as follows. A gallery, or passage, is cut into the face of the hill; with such slight declivity outwards, as is sufficient to carry off the water. Where the rock may happen to require it; frames of timber, rudely, and even carelessly constructed, are set up: to support the roof and sides; and save the miner, from being crushed. Accidents, however, do happen: and men are, sometimes, lost. The size, or section of the gallery, is always small: in those parts, where the hardness of the rock, occasions any difficulty in working it; scarcely sufficient to admit a person, in a creeping posture. In no place, will it admit of an erect position.

The ore, as well as the rock, is detached by means of a very inefficient pick: and by chisels, or cutters; and hammers.—It is removed from the mine; on skins, drawn along the floor of the gallery, by boys. In some mines, great part of this work must be performed in a creeping posture. The ore being delivered at the mouth of the mine; is reduced to small fragments, by the hand. At *Dhanpúr*, however, this work is done by the *panchakki*, or water mill. It is next roasted in an open fire, or forge hearth; the fuel being charcoal; and the heat occasionally urged by two air bags or skins, which are alternately shut and opened by the hand. After being thus imperfectly roasted, it is smelted: but for this important operation, the same forge hearth is made to serve; and the process is repeated, till the metal is sufficiently refined. I do not know of any flux being used; to accelerate the scorification, and separation, of the less valuable metals.

The whole system, thus briefly described; is evidently, extremely rude, and inefficient. Worse methods, I do not think, could well be devised. They are, however, the natural result of the contracted views and want of enterprise, of the native character. It would, probably, be difficult to convince them; that any system of working, requiring an increase of outlay; could possibly be equally advantageous. It is hardly to be expected, therefore, that they will ever adopt any improvements of this kind: until at least, they can have the proof of direct experience; in favor of the greater profit, they may bring. Any important amelioration of the system, must then proceed either from the Government, or from some European capitalist: and when the advantage of the new methods shall be clearly seen in an increased produce, and improved quality of metal; it is possible that then, but not till then, the mountaineer also, may begin to adopt them.

In England, the copper mines present a scene, perhaps, the first in the world, (except in the coal-mines of the same country) for commercial enterprise, scientific combination and mechanical skill. Such a system has been the growth of circumstances; and is only fitted to those circumstances, and to that country, in which it orginated. To attempt working these mines, on any thing like a similar scale; would be absurd: at least, before the productiveness of the several repositories of the ore, be clearly ascertained; and facilities of transport created, which do not at present exist. But, there are many modifications and improvements, which seem perfectly fitted to the state of things in the mountains; and which would involve little additional expence to the present outlay. In fact, there seems a wide interval, between the Chilian and English systems; while the modifications here contemplated, would probably, stop short of, even, the former. Supposing the expediency of such improvements, or a part of them generally admitted; they must, I think, to have justice done them, be introduced under the orders of government, in some mine, the lease of which may be retained for the necessary period. They would, at least, have the good effect of enabling us to obtain better data; for judging, whether or not, any further improvements and extension of the system, would be advisable. In the former case, experienced and practical people might be invited from England; for the purpose of improving the various operations of mining, roasting, smelting, refining the ore, &c.

The improvements which appear to me suited to the actual condition of things are as follows. The present narrow and inaccessible galleries should be enlarged; so as to admit, not only of an erect position, but of a man's working with effect, in them. This, of course, only applies to such as furnish a sufficient supply of ore; or to new galleries just commenced. Vertical shafts should be sunk when advisable, so as to admit of the ore being followed with effect. In many cases, however, this would be perfectly impossible; from the nature of the mountain, in which the mine is situated. Strong and effective timbers should be put up, for the support of the rock, when at all likely to fail: and to effect all these purposes, proper tools, made of good iron; and not the inferior kind, at present used; should be provided. The method of splitting rocks, by the wedge; and by blasting; might be introduced with advantage: and generally, such other practical improvements, as, though readily suggesting themselves on the spot, are not easy to be enumerated connectedly.

With regard to the drainage; the present system is, perhaps, the cheapest that could be devised, as far as it goes: but it is only calculated to meet, one, of many numerous cases occurring in practice. Should the ore be situated below the level of the mouth of the mine; some method is then required to raise the water, which will flow into the new excavation, to that level, at which it may flow out. At present, I am inclined to think, that much valuable ore is lost; owing to the difficulties which present themselves, when the bed or vein sinks to an inferior level. And it is certainly, to the absence of water, in the *Dhanpúr* mine; and the consequent facility of following the ore, in all its deviations; that its higher value in the scale, is mainly owing. Simple methods of raising water, might then, I think, be advantageously employed: such as the endless chain of water pots, used in the upper provinces; or a pump, or set of pumps, to be worked by manual labor. In raising water or any weight; where great power is required; one of the most useful mechanical inventions, is the double capstan: a contrivance, which is at once, eminently cheap, simple, and efficacious. In many cases, where the deposit of ore has a downward direction; a second gallery, at a lower level, may be conveniently established: probably, in most cases, this method of double galleries might be advantageous. A great progress must be made in the system here contemplated; before a Steam Engine, even of small power, could be introduced with any thing like a prospect of profit.

I have mentioned the principal points of improvement in working the ore. In delivering it from the mine; wheel barrows; or still better, sledges on four wheels, should be adopted; instead of the skins at present used. It seems, however, doubtful, whether the introduction of goats, to draw such sledges, would be any improvement. They are used extensively in the upper mountains, for carrying burthens.

In reducing the ore to fragments; the *Dhanpúr* miners employ the *Panchakí*, or water mill. When water is present, no better plan (I mean consistent with the economy here contemplated,) can be devised; when water is not to be had, in sufficient abundance; a simple arrangement of stampers, might be preferable to the method of doing it, by the hammer.

It is, however, in the roasting, and smelting operation, that the greatest room for improvement is to be found; and the greatest prospect of advantage from a change; as the immediate effect of this would be, to raise the value of the metal produced. For the present open hearths, and air bags; I would substitute a system of reverberatory furnaces; of different draughts, for the two different processes, of roasting and smelting. An excellent material for constructing them is at hand, in the rock, I have called potstone. Perfectly compact, and equal to any resistance; infusible in the strongest heat; while it is so soft as to be cut with a knife; it is difficult, even to imagine, any substance better fitted for such work. It might be advisable, in an economical point of view, to construct the roasting furnaces in such a manner, as to collect the sulphur at present lost; an object not difficult to be effected.

Even the introduction of the simple blast furnance used in Chili, (and nothing can be simpler) would be an immense improvement. It is of a circular shape; similar to a lime kiln; and covered with a dome, to confine and concentrate the heat. The ore is arranged in it, in alternate layers with the fuel, which is wood; and being lighted, it continues burning for a considerable time. When required; the heat is urged by a double pair of bellows, worked by a crank, turned by a water mill. The mere substitution of an efficient bellows, for the air bags, used at present, would be no trifling advantage gained; but I am of opinion, that a wind furnace is greatly preferable to all these half measures, in the saving of manual labor. Nor is it so much more expensive, even at the outset, as might be imagined.

The methods of reduction practised in England; where, certainly, the subject is best understood; vary with the ore, and even with the establishment: but the differences are trifling, and affect only the minor details. The two great objects to be effected, are—first, by a properly regulated heat to drive off the volatile ingredients, sulphur, and arsenic; and to oxidate the iron, thereby promoting the fusibility of the ore, and consequent separation of the copper from the scoria when in fusion: and, secondly, by an intense and properly directed fusing heat, to effect the vitrification of the impurities; which thus form a slag at the top, and are skimmed off, while the metal sinks down in a comparatively pure state. To promote this vitrification of the ingredients, occasional additions are made to the ore, as the case may seem to require; though, in general, the run of the ores is such, as to require little beyond a few slags of an old smelting. Calcareous flux has been used at some works; and this is at hand in the mountains. A most valuable and effective flux, for the reduction of ores, in the small way, (for experiment) is borax. Whether it might not be used on the large scale, here, where it is so much cheaper than in Europe; may require some consideration, and some practical trials.

The operations of roasting and smelting are repeated several times—each smelting being followed by a roasting—to expedite which effect; the copper is after each smelting, but the last, let into water to be granulated. This separation of the metal into such small parts, assists of course, the calcining power of the furnace, and the work is more speedily effected than if performed on the mass. After the last smelting comes the process of refining, or poling, as it is technically called. It consists in keeping the copper in a melted state, covered with charcoal; and introducing from time to time a wooden pole into the melted metal; which causes considerable ebullition, owing to the evolution of gaseous matter. It is occasionally assayed, in order to judge how the process is going on; by taking out a small portion, allowing it to cool, and breaking it in the vice. By the colour and general appearance of the fractured surface; a judgment is formed, as to whether the poling has proceeded far enough. This operation which gives the metal that perfect appearance, always looked for in the market; is unknown to the mountaineer. It is probable, that it would materially improve the quality; or at least, the appearance of the article.

Lead is sometimes used, both in Hungary, and England, to expedite the previous operations of the refinery. The oxides of this metal, are amongst the most powerful vitrifiers known: as such they are effectual in the assay and refinement of the precious metals; and as such they may be used also with copper: but the process requires attention, as if not stopped in time, or too much lead added; the copper itself will be oxidated and vitrified. Applied with proper caution, it would, no doubt, be a most useful material to the mountaineer; and the occurrence of this metal, in the vicinity of the copper mines, obviates every objection on the score of expence.

On the supposition of Government establishing an experimental mine; I would propose that all the different processes of mining, extracting the ore, removing it, for pounding, roasting, smelting, refining, &c. should be performed by the job, and nót by the day. This, which is one of the most important improvements in modern management, is particularly necessary on a new experiment; because it makes it the interest of the people employed, to co-operate with, instead of endeavouring to thwart us: the implements, tools, apparatus, furnaces, &c. to be all furnished at the expence of Government; and a given tale established for the different kinds of rock and ore, both for removal from the mine, and for the calcining and smelting of the latter.

2.—*The Iron Mines.*

The foregoing includes all that immediately suggests itself, as feasible improvement in the management of the copper mines: I have proposed,

posed, I think, no charge that would not, in a very short time, more than repay the expence incurred. With regard to the iron mines, I shall also mention a few particulars; which, if attended to, would materially increase the revenue derivable from them also. I am informed by the Commissioner that the united rent of these mines, which are very numerous, does not exceed the sum of 1500 Rupees per annum; while the iron is of the very worst quality, and yet bears a price, in the Almora[*] Bazar, not much less than that of the best English iron, deliverable at Bareilly.

The process of manufacturing iron from its ores, is so far different from that of copper; in as much as, none but the *oxides* of the former metal are ever employed. In the copper ores (that is, in those which occur in any quantity;) the metal is combined with sulphur: which can be only driven off by repeated roastings; employing such a draught of air as to acidify it, the more effectually to separate it, in the latter stages. In the iron ores; the metal is united to oxygen; and mixed with various earthy impurities. In reducing these ores then, there are three distinct points to be attended to—First, the provision of a substance, which shall effectually take the oxygen from the ore; leaving the metal mixed, only with its earthy constituents: 2ndly, The proportioning the flux used, to those earthy ingredients; so as to ensure a complete vitrification of them, and separation from, the metallic particles: and 3dly, A sufficient heat, to fuse the latter; that the separation, and reduction, may be more complete. The first point is attained, by using a sufficient quantity of charcoal, in the reduction of the ores; the second, by adding, as the ore may require it, limestone or other flux; and the third point is only to be effected, by using a powerful blast furnace. Though it be, no doubt, possible to construct wind furnaces, of such draught as should smelt iron; still it is, I believe, more economical, as well as more certain, to trust only to a powerful blast.

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[*] Almorah, 8 seers, 1 Rupee—Gwalior iron, good, soft, 6 seers—at Moradabad, hill iron ditto but hard, good for *fouras*—Swedish steel, 2 seers—English cast, 2½—English iron, bar, 4—in flat bars, 4¾.

The mountaineer reduces his iron ores in the manner already described for the copper ores. But from the imperfection of the method, the great waste of heat and non-employment of a proper flux in refractory ores, the iron is never smelted, but comes out of the furnace in porous knobs very much the size and shape of the original pieces of ore. These might, however, with proper management, be manufactured into a saleable iron; but the miner is contented with selling them in this state to the blacksmiths who, again, are very sparing in labor when shaping them into the pigs in which they are finally sold in the bazar.

In as far as such a lazy process may be compared with one which furnished metal of the very best quality, we may say the mode practised in the mountains is similar in its general features to the ancient methods which prevailed in Europe. These have, however, long been superseded by more economical processes, each of which is adapted to the particular kind of fuel and ore of the country in which it is employed. The English method, which employs coal as the fuel, does not require to be considered here; but the Swedish, in which charcoal is the fuel used, appears from this circumstance, from the simplicity of the apparatus and the small outlay of capital required, particularly fitted for these provinces, and not unworthy of attention and encouragement from the Government. It is well known that the superiority of the Swedish iron over the English, is mainly owing to the nature of the fuel used; although it is *also* true that the Swedish ore is chiefly, if not entirely, of the first quality—MAGNETIC IRON ORE. The former advantage ought also to hold in the case of the mountain iron; but none of the working ores, it must be confessed, that I have yet examined, excepting one, is of the same species, as the Swedish.

Specimens, however, of this ore have been found in different places; and it is very probable that it does exist in sufficient quantity, to become an object of consideration to the Government. The *Bundelkhand* iron, which is said to be one of the best after that from *Gwalior*, is manufactured from the red oxide. The *Gwalior* ore I have never seen; but conclude it to be of the magnetic species, from a circumstance I recollect being mentioned by Captain Gerard, when surveying that country, of an unusual deviation of the magnetic needle. The mountain iron would, however, if carefully manufactured, have a sufficiently fair market, without any chance of being interfered with by either of those other kinds: and even supposing that the common ores should hold out little inducement to expend much on improvements in their reduction; still in the one known source of the magnetic ore, there is, apparently, a sufficient supply to authorize at least an experiment on a small scale.

It may, perhaps, be said, that a full improvement of the quality of this iron, would interfere with the sale of English iron: but it appears to me, that it would chiefly supply the place of the Swedish in the market; which is known to be in great request amongst the natives, under the name of "Francese Loha." English iron has not an extensive sale in India; even in England it is now well established, that all the best steel is manufactured from Swedish iron. English bar iron, however, bears a higher price than the *Gwalior* iron; though the latter is more extensively used amongst the natives. The former is sold at *Moradabad*, for 4¾ seers the Rupee; the latter at 6 seers. The mountain iron sells on the spot for 6 seers generally, that is about £14 a ton, which was the highest wholesale price to which the English iron attained during the war; at present

sent it is little more than £10. The mountain iron could be afforded at a much cheaper rate.

The chief points, in which improvement is desirable, will be evident from what I have stated (Art. 30). The erection of proper blast furnaces; the judicious employment of fluxes; and a more careful system of manufacture; are all that is required to raise the quality of the metal, according to the ore used, either to a standard with the English iron or the Swedish. In the erection of blast furnaces, there seems no difficulty in a country where water is to be commanded at every turn. Limestone, one of the fluxes most used, is at hand; and all that seems required is a careful superintendence, to shew the advantage of the new methods in the first instance.

These being once established, it appears probable they would be generally adopted, when the object is to furnish so generally useful a metal in a purer and more workable state. I have said nothing of the process required for bringing the fused metal into a malleable condition, as it offers no difficulty. Water may here also be advantageously used as the moving power for the great sledge hammers, with which the fused metal is to be beaten.

The iron ores all belong, with the exception of those of two mines, to the species called RED OXIDE (*fer oligiste* of HAUY). This is a peroxyde of iron; containing, in its best-defined type, seventy per cent. iron, and thirty, oxygen. The working ore, however, often contains earthy impurities, which reduce the proportion as low as fifty per cent. of metal.—RED HÆMATITE, a variety of this species occurs in a very extensive bed in Gneiss at *Dhaniakót*, on the *Cosillah*. It frequently contains small veins of MICACEOUS IRON ore of a highly splendent lustre. At *Ramgár*, on the road from *Bhamáori* to *Almórah*, it passes into the variety called SCALY IRON ORE, consisting of loosely cohering glimmering particles of a steel grey or iron black color, strongly soiling and feeling unctuous to the touch. These beds, though distant many miles, are, I think, connected beneath, and from one and the same deposit.—Both of these varieties are said to yield very good iron; the first, particularly. COMPACT RED IRON ORE, occurs in a clay slate containing beds of lime-stone at *Katsári*, on the *Rámganga*, in masses composed apparently of fragments more or less angular, reunited by a stalagmitic incrustation. The iron manufactured from it is esteemed the best in the province of *Kamáun*. It is the only ore which has any adjunct of calcareous matter; and to this adjustment of the flux by nature, is attributable, I think, the superiority of the iron produced. Near *Kalsi* on the *Jemna*, there is an extensive bed of SPECULAR IRON ORE. The specimens which I have examined were fine granular, approaching to compact.

In *Chawgarka* purgunnah, one of the excepted mines, the ore is the YELLOW (or *hydrated*) OXIDE. It is of two varieties, the ochry and compact. The former sometimes contains octahedral crystals of magnetic iron ore, and in the neighbourhood of the mine, on the summit of a small hill, there occur rolled pieces, composed of grains of quartz, and small octahedral crystals of this mineral, cemented together. These pieces are magnets, and have each two poles. The ores of this mine contain manganese in small proportion, and would, consequently, afford a very good steel; as it is to the alloy of this metal that the superiority of the steel manufactured from some of the brown iron stones, is generally attributed. The other exception is the mine at *Sil*, in *Biseher*, where a mica slate occurs with disseminated crystals, or grains of MAGNETIC IRON ORE; in such quantity, as in favorable specimens, to equal half the weight, or one-third the bulk. Some pieces of this slate have a specific gravity of 3,45. That of the ore itself is 4,8. The stone is reduced to powder by hand mills; and by means of a running stream, all the impurities are separated. There remains a black sand; which however still contains about a fifth of its weight of impurities: this is smelted with charcoal, into a porous mass; which imperfectly beaten, is sold to the lower mountaineers at the rate of eight and a half seers for the Rupee. The iron is said to be of excellent quality, and is in great demand for *Khúkerís*. This is the mine at which I think it very desirrable some improvements should be attempted, as holding out a fairer prospect of advantage. There does not appear to be any reason why this ore, if carefully reduced, should not furnish an iron fully equal to the Swedish. The supply, too, is sufficient to justify the expectation of a considerable addition to the revenue. At present, the people state the produce of manufactured iron as not exceeding three hundred Rupees; but from the flourishing and substantial appearance of the village, I should think it must greatly exceed this sum.

3.—*The Lead Mines.*

The LEAD MINES are numerous, and the supply of ore from some of them has been considerable. The most valuable are situated on the river *Tonse*, at no great distance from the *Dehra Dún*. There are three places where works, to some extent, have been, and are carried on; *Aíyar*, *Maíyar*, and *Borěla*. The first-named place is on the right bank of the river below the village of *Bhatnór*, and within the limits of *Sirmúr*. The other two are on the left bank, and are in *Jaúnsár*, one of the mountain purgunnahs retained by Government; the superintendence of which, is vested in the Officer commanding at *Děhra*. The *Borěla* mine formerly paid two thousand rupees yearly; the *Maíyar* one, four thousand: the present rents are six hundred and fifty; and one thousand. The mines were always included in the assessment for revenue; and latterly owing to their alleged non-productiveness, the sum assessed has been limited to the mere land tax of the mine at *Aiyar*. I could not learn any particulars regarding the rent, the people being uncommunicative.*

With regard to the truth of their assertion, that these mines have ceased to be profitable, it is very difficult to judge. They are still worked, which is a presumption against it, but without a personal examination of the several galleries, and they are exceedingly numerous, it is difficult to say positively whether this assertion be correct or otherwise. I have however little doubt but they might be made productive, by a more enlarged and perfect system of work; and I found this opinion on the great number of excavations, clearly proving the original abundance of the ore. It is not likely, that the several veins or beds, have been exhausted by a system of mining which admits of no ventilation; and has no galleries, exceeding probably two hundred yards in length. At all events some trials, and a closer examination, would seem to be advisable; particularly when it is considered that there has been a falling off in the revenue, amounting to upwards of four thousand rupees yearly. To offer the mines to the highest bidder, would not be likely to elicit any light on the subject. It is not probable that any mountaineer could be got to undertake the work in opposition to those residing on the spot,† and having the advantage of experience.

The mine at *Bhatnór* is situated in clay slate. The rock where the mine penetrates is so tender and fragmentary, as when removed from the mine to have all the appearance of angular debris. Owing to this circumstance. the roof of the mine, as well as the sides, have occasion to be strengthened by timbers. Notwithstanding which, they sometimes fall in, and the miners are killed.

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* The village belongs to the Rájah of *Sirmúr*.

† On account of the difficulties a stranger (if a native) would have to contend with; there would be, most probably, an organised opposition of the whole neighbourhood, to thwart him.

The ore is found, as I said, occasionally in quartz veins in the clay slate; occasionally in the slate itself. The ore at *Maíyar* also occurs in a clay slate; that at *Boréla*, in a bed of lime-stone, situated in the clay slate. At each of these places the rock is sufficiently firm to afford the greatest security, and no propping or timbers are required; but the labor of excavation is greater. At *Bhatnór*, owing to the softness of the ground, the galleries are roomy; and will allow of an upright position: at the other places, they are similar to the copper mines; low, narrow, and tortuous. The supply of ore has evidently been considerable, for the number of these galleries is quite surprising: at *Boréla*, I was told they exceeded eighty; and I see no reason to think that the statement is too high.

At all three places the ore IS the same, a steel grey FINE GRANULAR GALÆNA, having a specific gravity of 7,2; at *Maíwar* it is accompanied by IRON PYRITES, and in one gallery by SULPHUR. The mode of reducing these ores, is precisely the same as that already described for the copper ores; the sulphur being allowed to go to waste. Similar improvements suggest themselves as advisable; though as the metal is so much cheaper, and the process of reduction so much more facile, they do not appear to be so imperiously called for, as an amelioration of the system of working the copper. A singular fact is, that the ore and reduced metal sell, by weight, for the same price at *Kálsi*, the nearest town. I could not learn the reason of this; but suppose that the produce of sulphur, pays the expence of reducing the ore.